AMPLIFI
Prosperity Partnership

Optimising high-energy density physics in complex geometries for inertial fusion energy

first light

Imperial College London

Simon Bland, Francisco Suzuki-Vidal

UK Inertial Fusion Consortium Meeting
Imperial College London
27th Mar 2024

UNIVERSITY OF OXFORD

UNIVERSITY of York

Machine Discovery

UKRI Engineering and Physical Sciences Research Council

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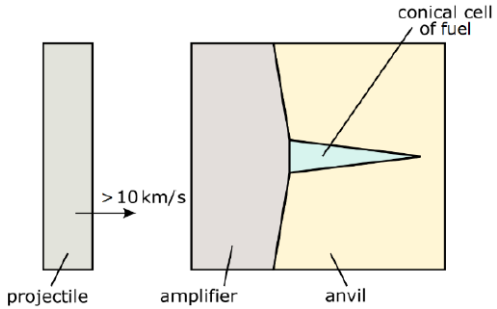
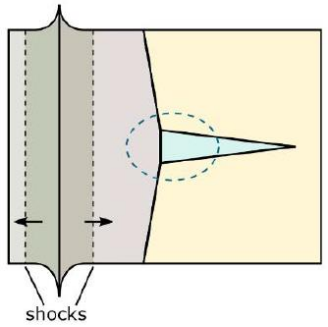
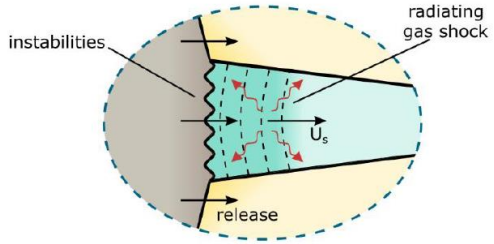
AMPLIFI: **AM**plified **PL**asma **I**nertial **F**usion **I**nitiative

- Explore the physics underlying more complex IFE target designs
  - **Move the complexity from the driver to the target**
  - **Significantly reduce the cost of the driver and power plant**
- Initial ideas were based around **'projectile' fusion**





Kaliski-type, surrogate experiment



But not wedded to gun/pulsed power driven projectiles – just single sided, shock-driven

- **Physics driven –** exploring **hydrodynamics, heat and radiation transfer** between complex boundaries of different material states (often with large differences in Z). **Experiments, simulations and theory hand in hand.**
- Whilst driven by **FLF business needs**, **results are open and applicable across HEDP / ICF** – e.g. high pressure EoS studies for planetary physics, heat transport in fast ignition experiments

Who are the staff involved?

Industry partners

first light

Francisco Suzuki-Vidal (Business Lead)
Claudia Gonzalez (Project Manager)

Nick Hawker (CEO)
Hugo Doyle, Nathan Joiner (HoDs)

Machine Discovery

Bijan Kiani
Christina Sweeney

Academic partners

Imperial College London

Simon Bland (Academic Lead)
Jerry Chittenden
Sergey Lebedev
Roland Smith
Omar Matar
Ellie Tubman, Grisha Kagan

UNIVERSITY OF OXFORD

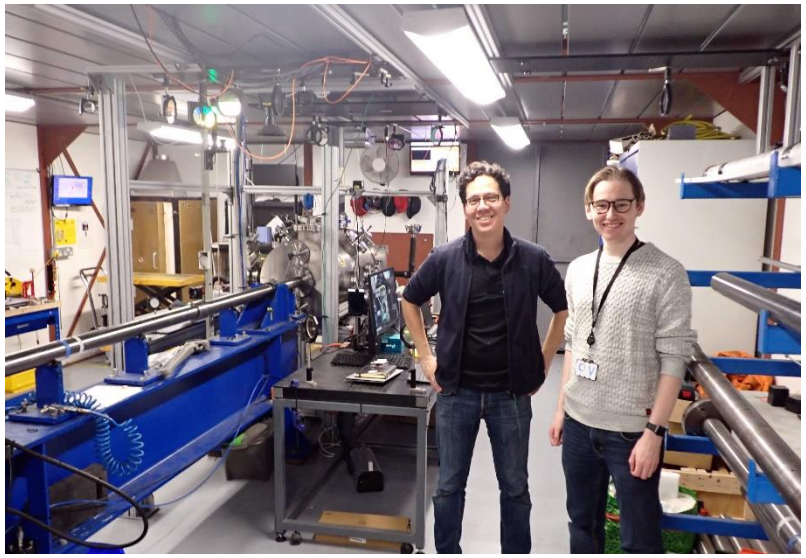
(Physics & Engineering)

Dan Eakins
Gianluca Gregori
Sam Vinko

UNIVERSITY of York

Andy Higginbotham
Chris Ridgers
Nigel Woolsey

What is the status?



Funding for **business-led research in collaboration with academics**

- **Total of £12M over 5 years** (£6M from EPSRC + £6M from FLF)

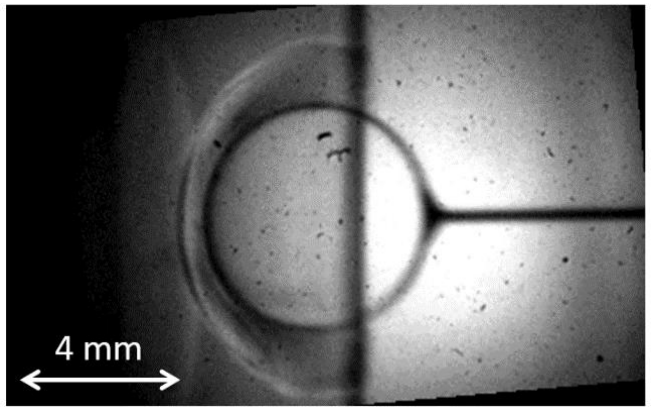
Funding includes

- **14x Postdoctoral researchers; 11 x PhD students; 40x Summer interns**
- **Helping build a new cohort of HEDS researchers in the UK**
- **Recruitment for Postdocs and PhDs has been progressing rapidly**

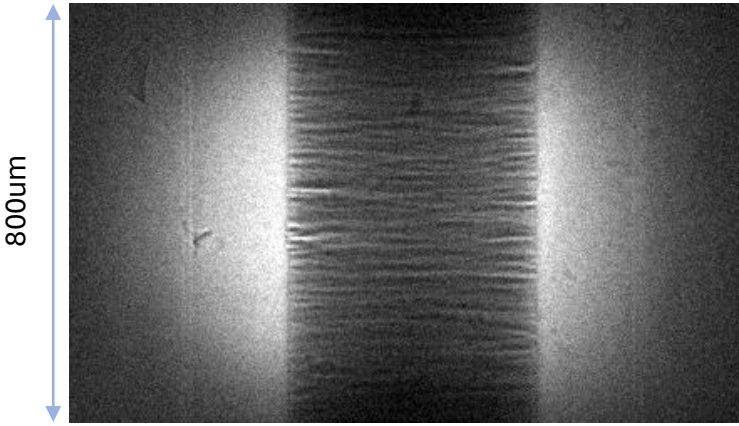
  - PhD, Oxford Engineering (Dan Eakins): **"Characterisation of hydrodynamics and energy localisation in structured targets under hypervelocity impact"**
  - Postdoc, Imperial (Simon Bland): **"Explore hydrodynamic instabilities, working with pulsed power experiments at ESRF, transfer measurements to gas gun experiments"**
  - Postdoc, Oxford Engineering (Dan Eakins): **"Impact and Shock Mechanics"**
  - Postdoc, Imperial Chem. Eng. (Omar Matar): **"Computational Fluid Dynamics to solve outstanding problems in FLF's Power Plant"**
  - **3 more postdocs start over next 2 months, 7 PhDs from October**

Research started on July 1st 2023

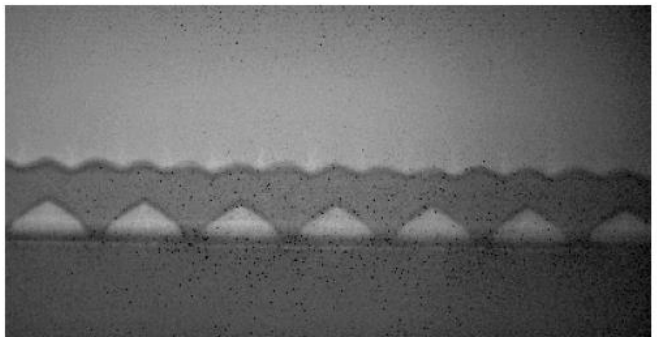
Low pressure hydrodynamic flow experiments by York on FLF's gas gun



Electrothermal instability measurements at ESRF by Imperial team



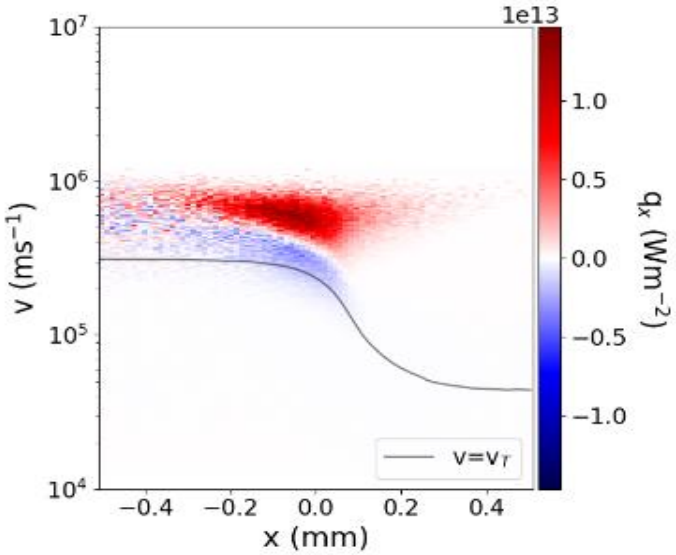
Control



Suppressed

Experiments to suppress RMI instability – Imperial / LLNL

Kinetic modelling of heat transport at York



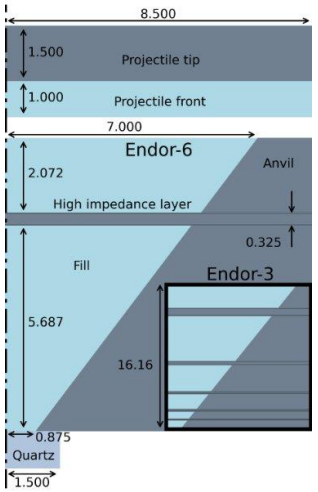
Some plans over the next 2 years

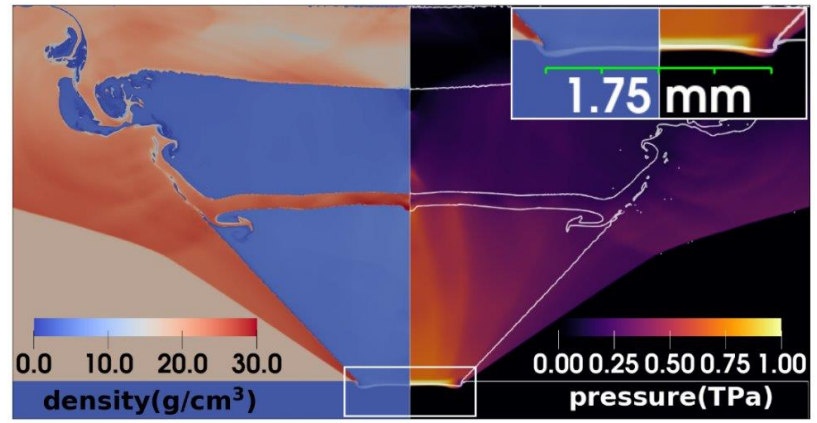
Heat transport	Radiation transport	Hydrodynamics
Heat transport coefficient calculations for Al, D2, PMMA **(York/Imperial)**	Explore Chimera code with Discovery Platform **(Imperial/Machine Discovery)**	Explore amplifiers at ESRF **(Oxford Eng)**
New platform for heat and radiation transport experiments **(Imperial)**	High-flux laser experiments **(York/Imperial)**	Liquid lithium flows for Power Plants **(Imperial Chem Eng)**
Plan experiments at LCLS and XFEL **(Oxford Phys/York/Imperial)**	Radiation transport coefficients using Open-MC **(Imperial)**	EoS models of PMMA under WDM conditions **(Oxford Phys)**

- Work with simulations to design platforms that isolate particular physics issues
- More 'joined up' experiments and simulation efforts, collaborating across partners to address stretch parameter space through WDM regime

Take advantage of FLF amplifiers

- Large increases in target pressure via combination of shock amplification via Mach reflections and shock multiplexing / stacking from layers of high and low impedance material
- Recently tested in Quartz EoS experiments via **Z Fundamental Sciences Program at Sandia**





On a 3 stage gas gun pressure of ~200 GPa obtainable

With Endor amplifier this increased to 1.1TPa over 0.75mm diameter with a hold time of 15ns

A Shock Amplification Platform For High-Energy-Density Physics: Accessing Terapascal Pressures On A Two-Stage Light-Gas Gun

J.W. Skidmore,* G.C. Burdiak, N. Niasse, V. Beltrán, H.W. Doyle, J.R. Allison, P. Allan, R.L. Barker, M. Betney, R. Bordas, D.A. Chapman, T. Edwards, E. Escauriza, N. Joiner, T. Kosteletos, J. Parker, J.D. Pecover, Z. Pešić, J.S. Read, M.P. Read, T. Ringrose, and N. Hawker
First Light Fusion, Oxford, OX5 1QU

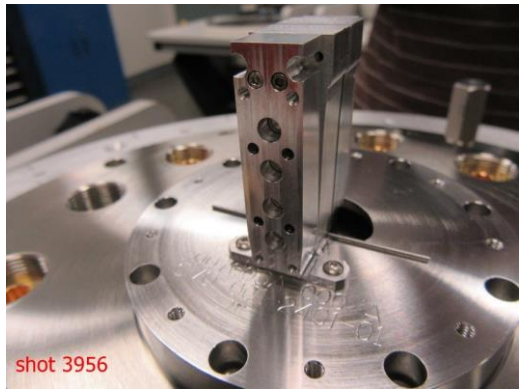
T. Ao, A. Porwitzky, D. Dolan, B. Farfan, C. Johnson, and A. Hansen
Sandia National Laboratories, Albuquerque, New Mexico 87185-1181
(Dated: February 18, 2024)

We present the "Endor" amplifier, a novel hydrodynamic pressure multiplier for high-energy-density physics studies. An equation of state platform using this technology has been developed for the study of terapascal pressures on two-stage light-gas guns. Validation experiments have demonstrated uniform pressures of 1.085 TPa in quartz over an area 0.75 mm in diameter with a temporal hold in excess of 15 ns. The temporal and spatial uniformity produced are suitable for high-precision equation of state measurements relative to a standard. This work substantially lowers the barrier of access to terapascal pressures by extending the capabilities of two-stage light-gas guns.

PRL submitted last week

Directors shot - using Z accelerator, 4 amplifier experiments simultaneously in Feb 24

Pressures of 1.85TPa (new facility record for quartz)



No precursor / pre-heat

Enables HEDP even on small gas guns, and at larger facilities record pressures – guns, pulsed power and lasers

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We're open to new collaborations!

with Vulcan upgrading, happy to help implement access to in house facilities across the Partnership