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UK Fusion: Inertial fusion in the UK
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Temperature

T

Confinement time

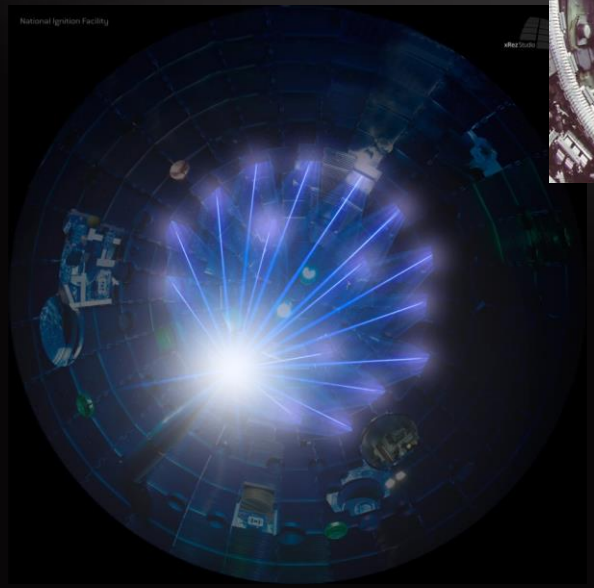
τ

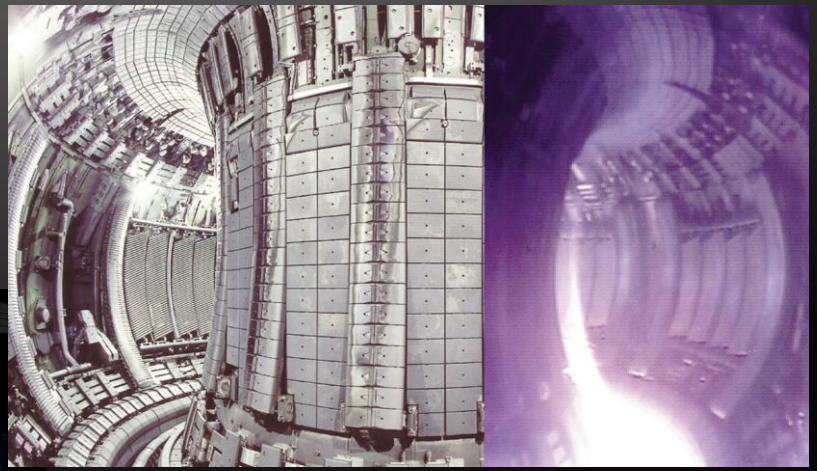
Density

n

The main approaches

Inertial confinement





Magnetic confinement

General principles of ICF

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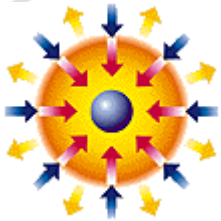
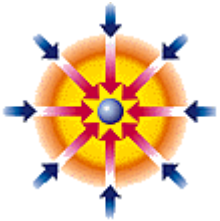
Lasers or X-rays symmetrically irradiate pellet



Hot plasma expands into vacuum causing shell to implode with high velocity



Material is compressed to ~1000 gcm^{-3}

Hot ignition region formed at the centre of the fuel by piston-like action of imploding shell

Implosion results in compression, heating and finally thermonuclear ignition + burn

Direct vs Indirect drive

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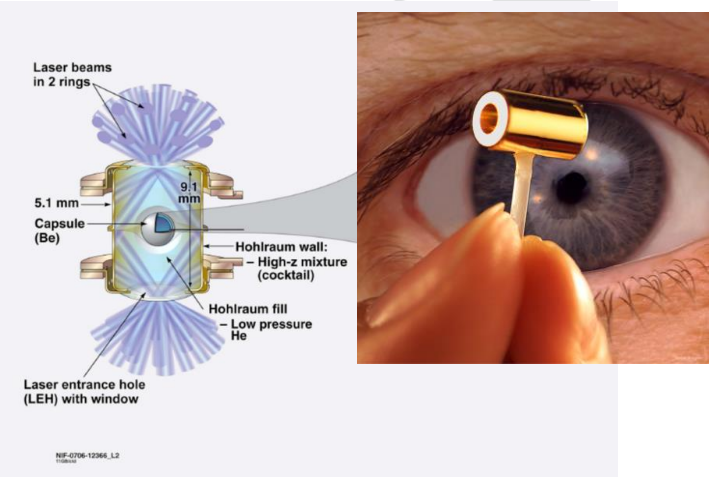

- Lasers fire into a gold can called a hohlraum
- The heated hohlraum emits X-rays
- X-rays are absorbed causing outer layer of capsule to ablate
- The rest of the fuel implodes to high density

- Lasers irradiate capsule surface directly
- Laser causes outer layer of capsule to ablate
- The rest of the fuel implodes to high density

Images courtesy of LLNL

Current scientific landscape

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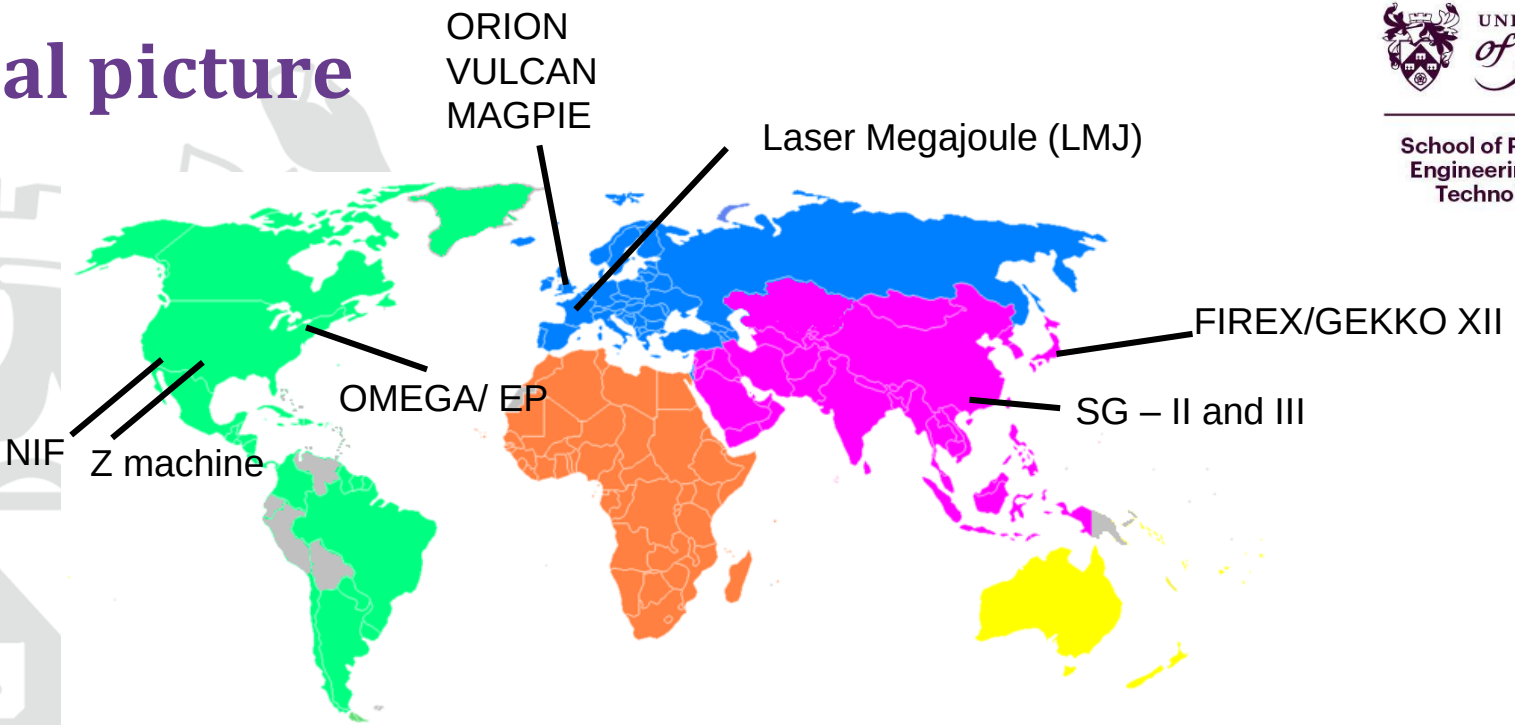
- The National Ignition Facility is a unique “ignition class” laser facility at LLNL, USA
- “Ignition” here is defined such that the energy obtained due to fusion reactions exceeds the laser energy delivered to the hohlraum
- After more than a decade of careful experimental and theoretical work, ignition was achieved for the first time on Dec 5th 2022 – 2.05 MJ of laser energy delivered to the hohlraum produced 3.15 MJ from fusion reactions
- Demonstration is robust - ignition has been reproduced on a number of occasions with increasing energy output.

Images courtesy of LLNL

Global picture



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Where does the UK sit?

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- Despite the community being relatively modest in the UK, we have a huge amount of influence
- We have been world leaders in high intensity lasers (VULCAN, GEMINI, ORION), targetry, theory, and computational modelling in high energy density science for many decades
- Many UK scientists based at LLNL(and US) and in the UK were involved in the ignition experiments (and work leading up to it)
- We have a huge role to play in the future of IFE – particularly since the UK and US have committed to a more joined up approach for fusion energy moving forward.

The UK Inertial fusion landscape

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The UK has formed the UK Inertial Fusion Consortium

It consists of ~90 members from: Central Laser Facility, Imperial College, University of Warwick, University of Oxford, AWE, University of York, University of Strathclyde, Queens University Belfast, University of Lancaster, First Light Fusion

It was established to foster collaboration, coordination and establish a collective voice within UK inertial fusion research

The consortium have created a UK inertial fusion roadmap covering the period 2021 – 2035

Inertial fusion energy is part of Fusion Futures envelope and there are funds to support some of this activity

Chair: Robbie Scott (Robbie.Scott@stfc.ac.uk)

https://www.inertial-fusion.co.uk

The UK Inertial fusion roadmap

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The strategy recommends the UK focus on two main areas of research

- High fusion-energy-gain laser fusion schemes
- The science of ignition

The roadmap focuses on the following areas

It also gives high importance to growth of community, EDI, and training

More detail can be found here: https://www.inertial-fusion.co.uk/roadmap

Resources

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NIF ignition
https://www.nature.com/articles/d41586-023-04045-8

https://journals.aps.org/prl/abstract/10.1103/PhysRevLett.132.065102

https://journals.aps.org/prl/abstract/10.1103/PhysRevLett.129.075001

High Gain ICF schemes
https://royalsocietypublishing.org/doi/10.1098/rsta.2020.0028
https://royalsocietypublishing.org/toc/rsta/2021/379/2189

UK Inertial Fusion Consortium
https://www.inertial-fusion.co.uk