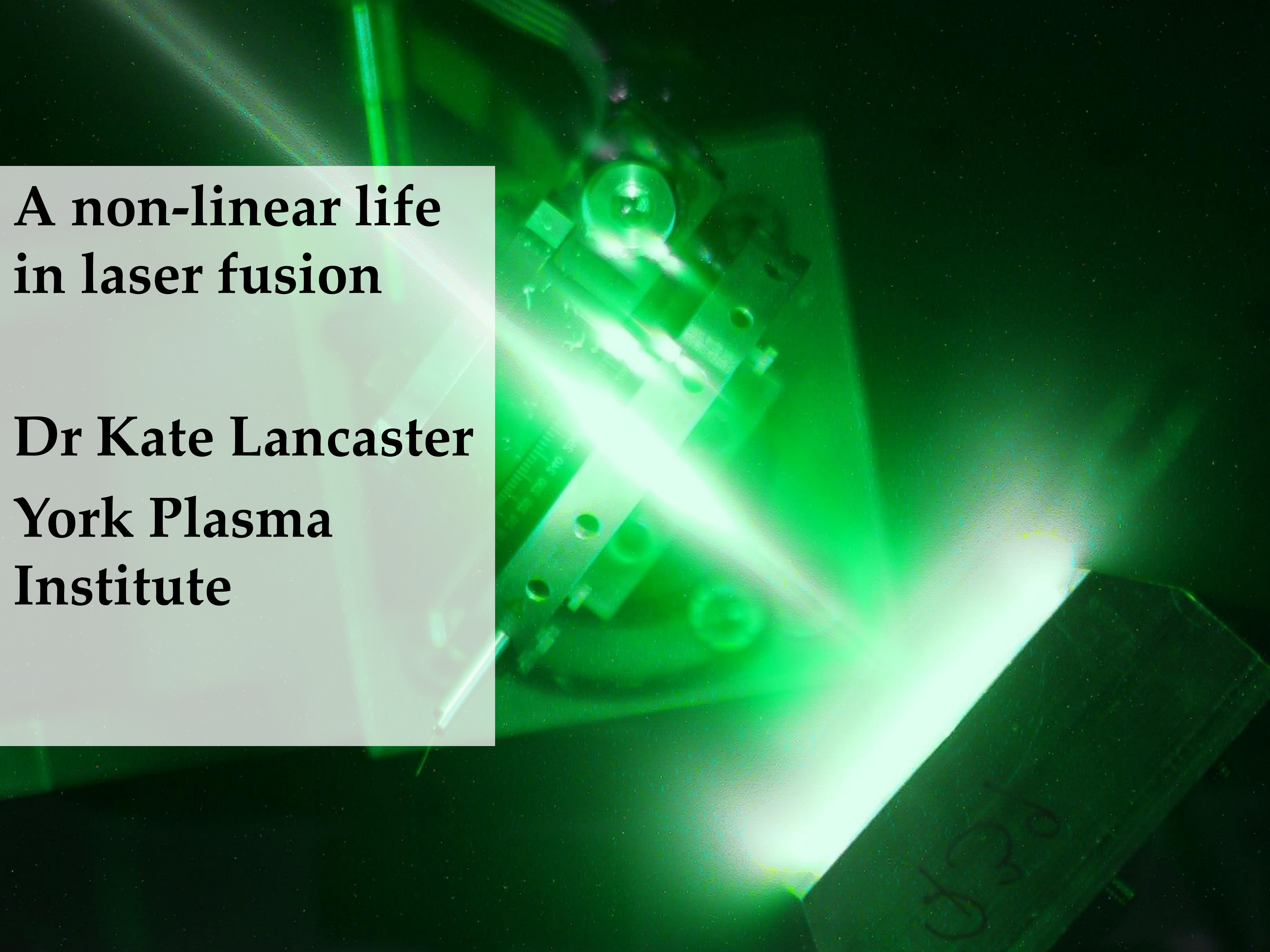
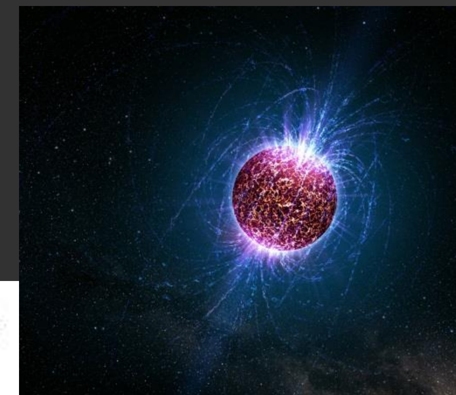


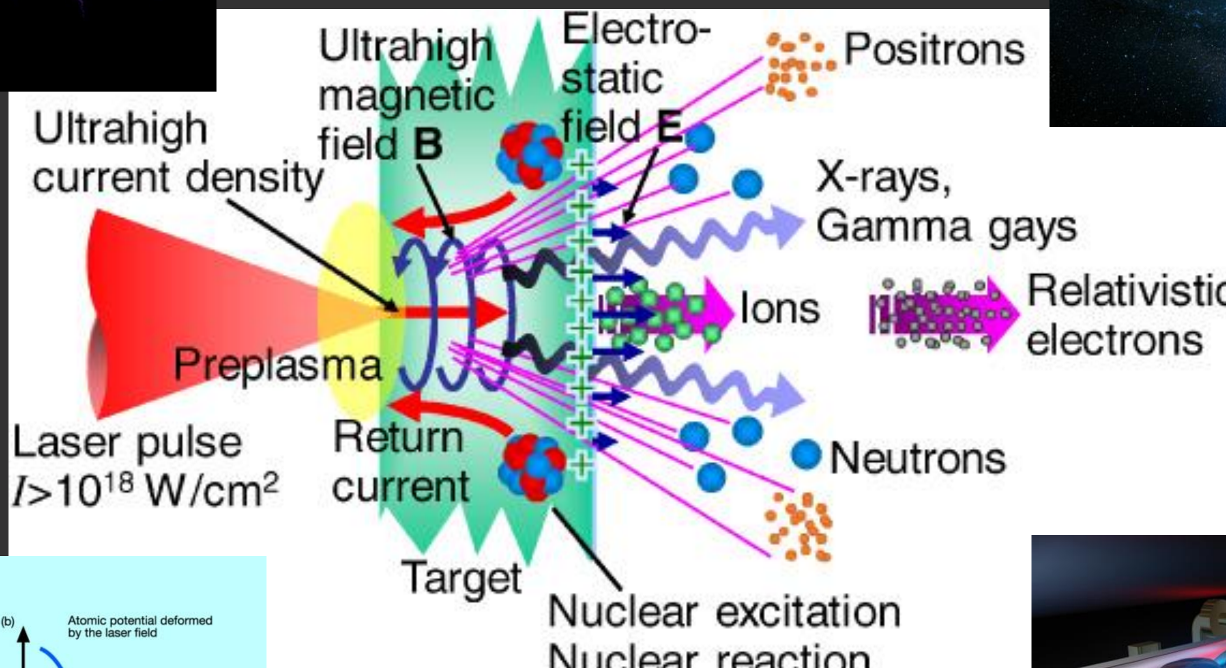
A non-linear life in laser fusion

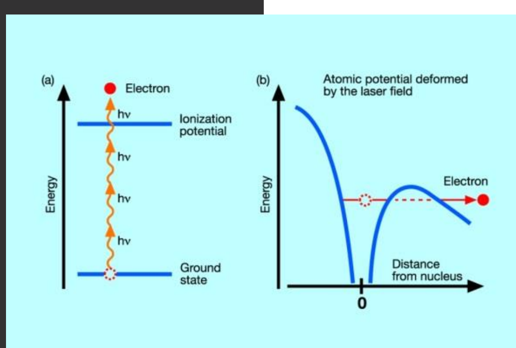
Dr Kate Lancaster

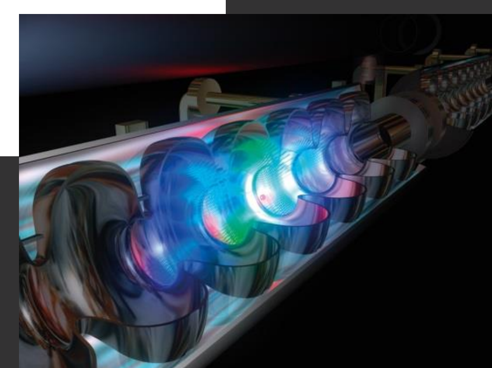
York Plasma Institute

All the physics, ever

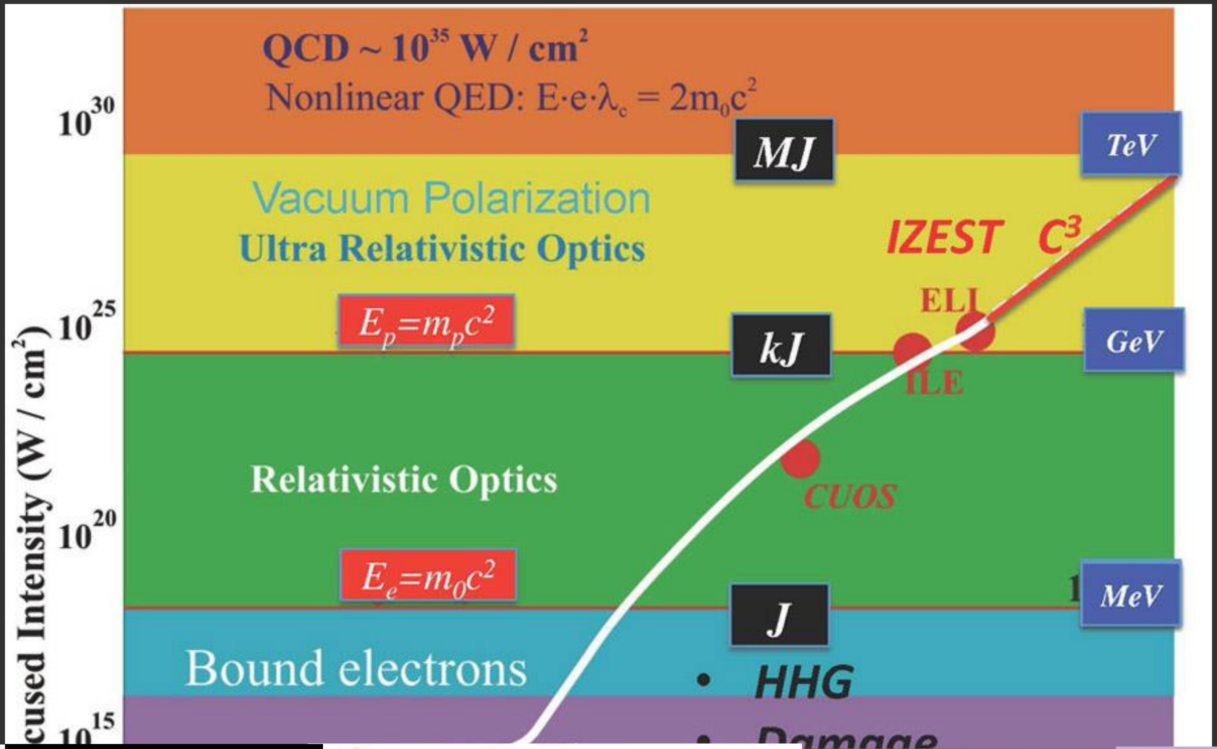


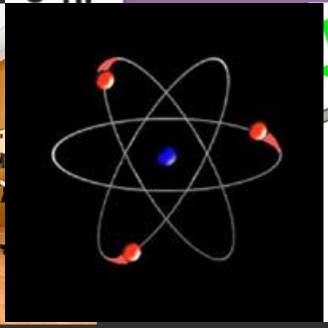


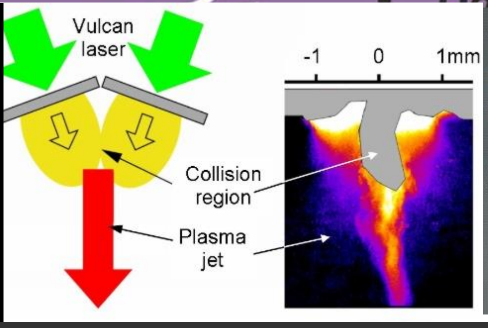


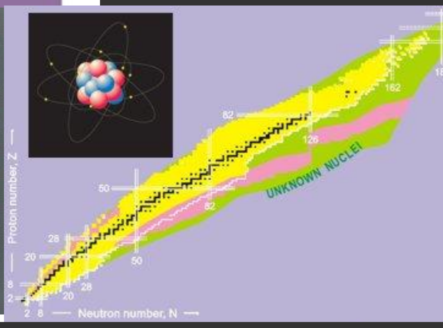


Laser regimes

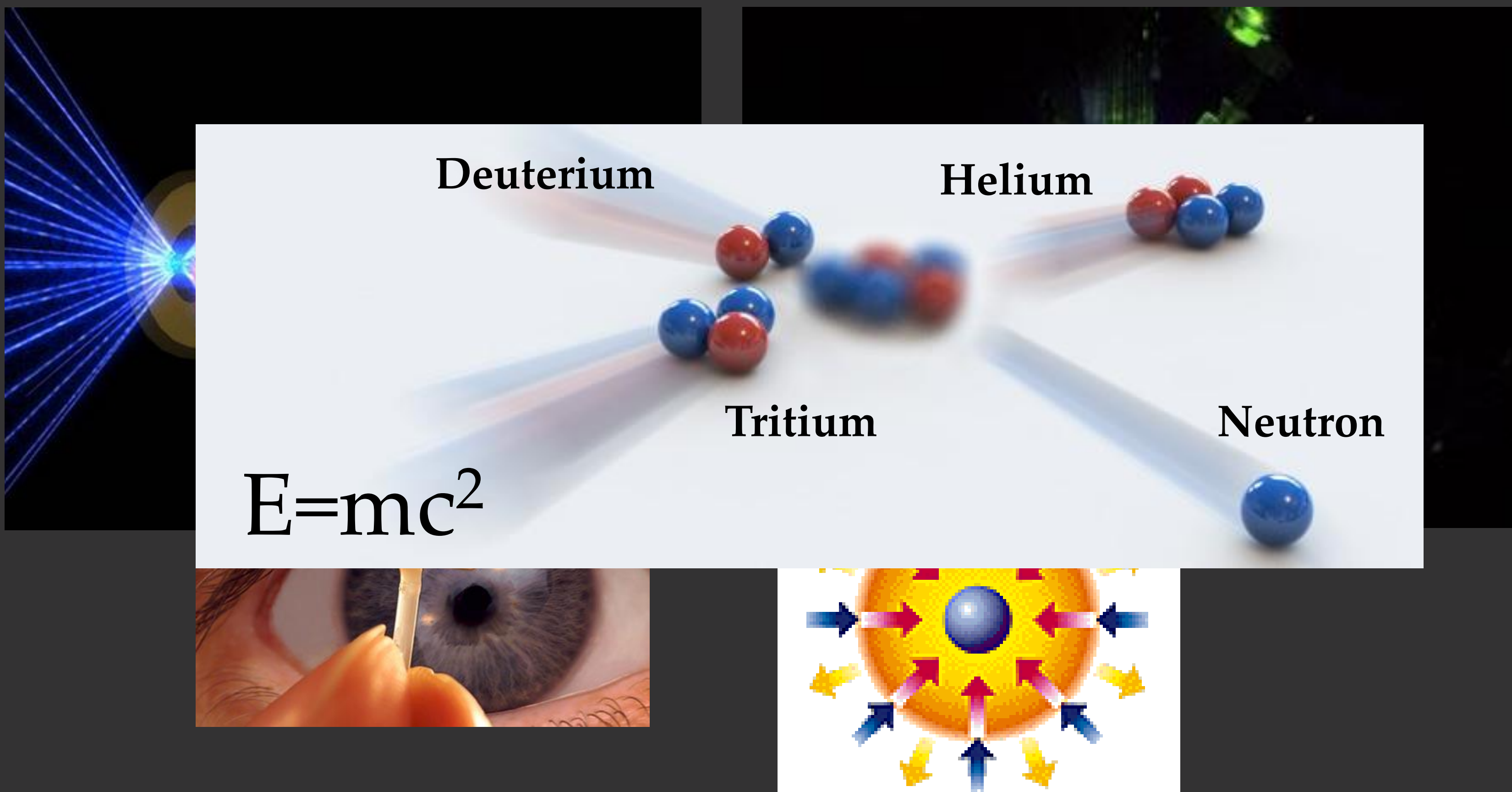




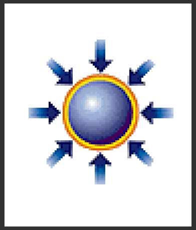




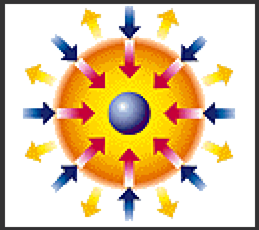
Inertial Confinement Fusion



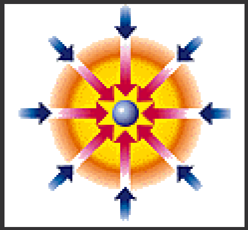
How it works



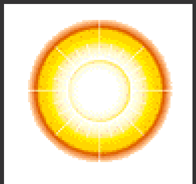
Laser irradiates capsule – laser is absorbed at the critical surface (where laser freq=plasma freq) and energy is conducted to higher density material



Higher density material heats and blows off (ablation), rest of fuel is compressed to 1000 x solid density via rocket action



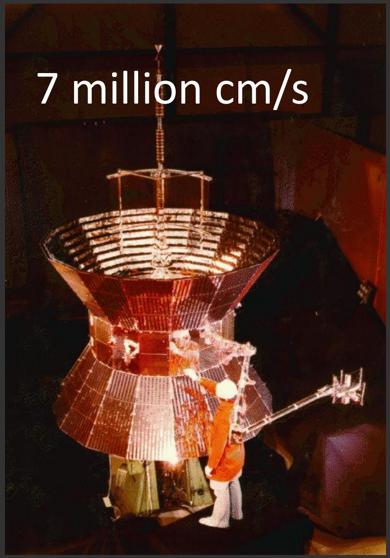
Shocks forming as the fuel compresses converge in the compressed fuel and raise the fuel to 100 million degrees Kelvin



Due to alpha particle deposition the fusion thermonuclear burn propagates through the fuel

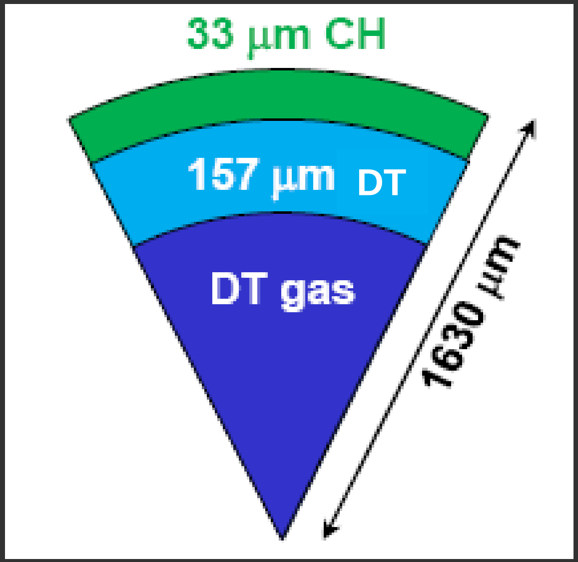
NOTE: Overdense – plasma above critical density
Underdense – plasma under critical density

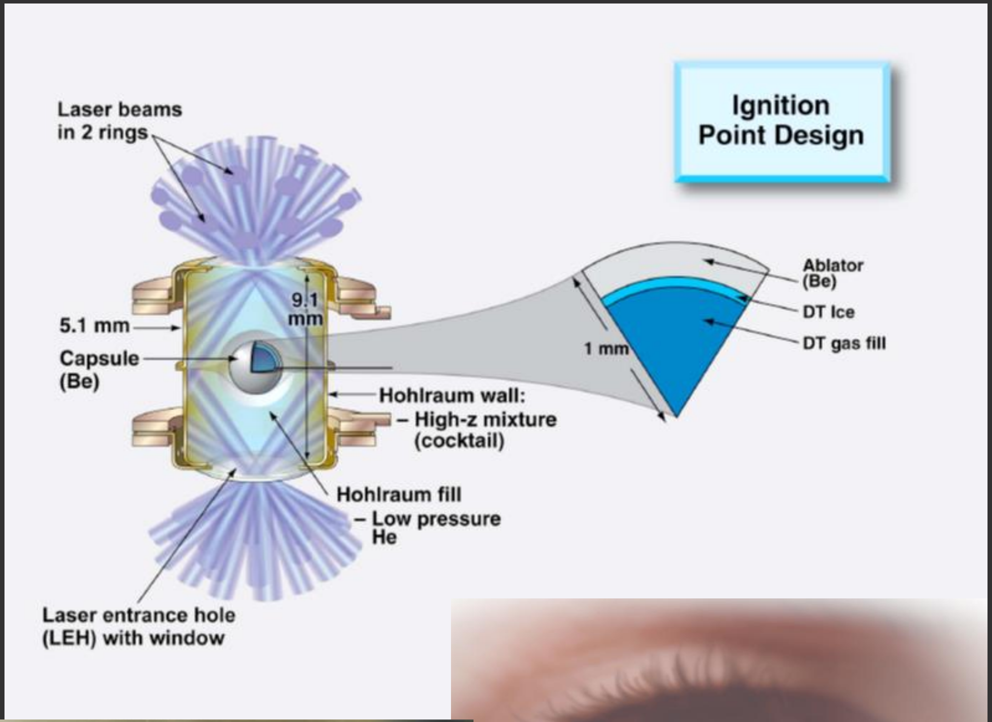
Numbers

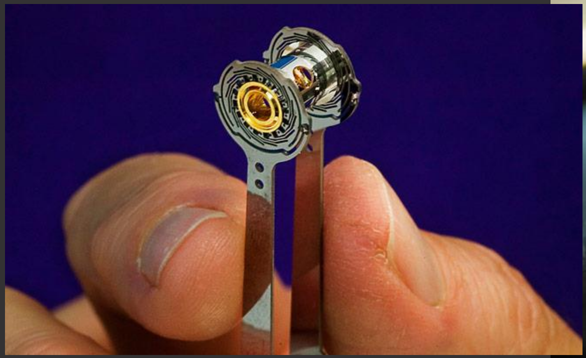


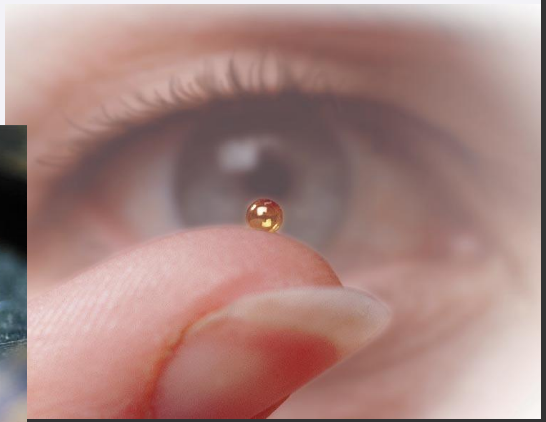
Ablation velocity: ~10^7 cm/s
Implosion velocity: ~10^7 cm/s
Ablation pressure: 100s Mbar
Peak pressure: 100s Gbar (pressure amplification due to spherical convergence)

Targets

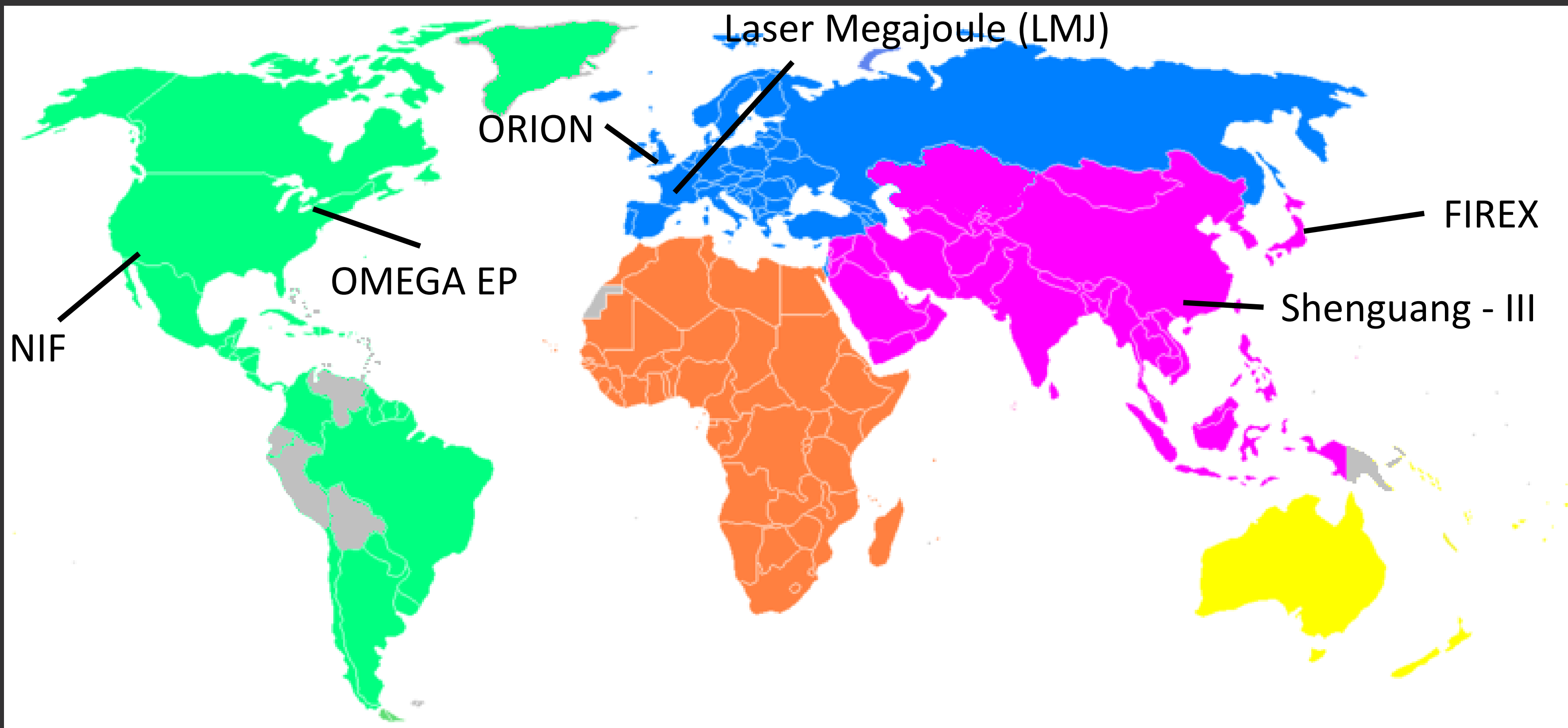

33 μm CH
157 μm DT
DT gas
1630 μm


Ignition
Point Design
Laser beams
in 2 rings
5.1 mm
9.1
mm
Capsule
(Be)
Hohlraum wall:
– High-z mixture
(cocktail)
Hohlraum fill
– Low pressure
He
Laser entrance hole
(LEH) with window
1 mm
Ablator
(Be)
DT Ice
DT gas fill



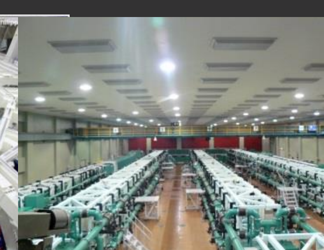


Major places to do ICF









University of York

The National Ignition Facility

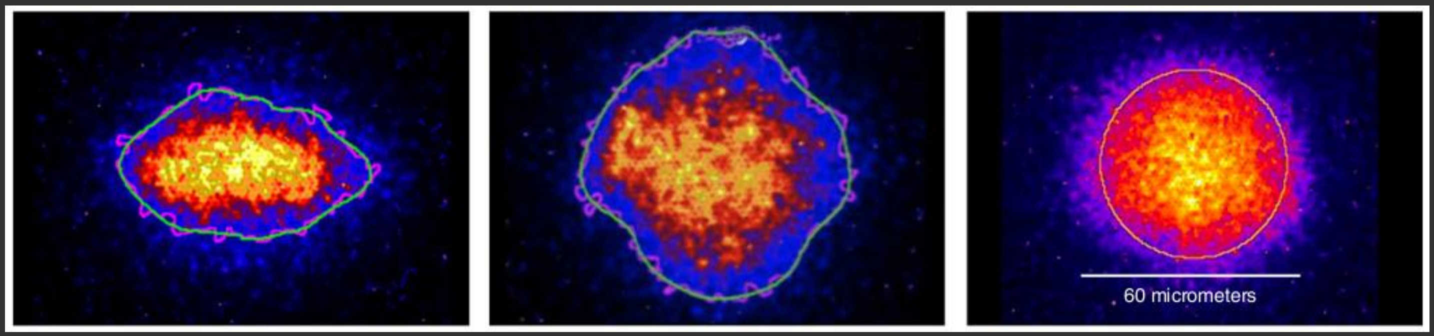
Spec:
λ= 0.35mm
Total energy (to target) = 2 MJ
Pulse length = 20 ns
Number of beams = 192
Beam configuration = polar
Scheme = Indirect drive

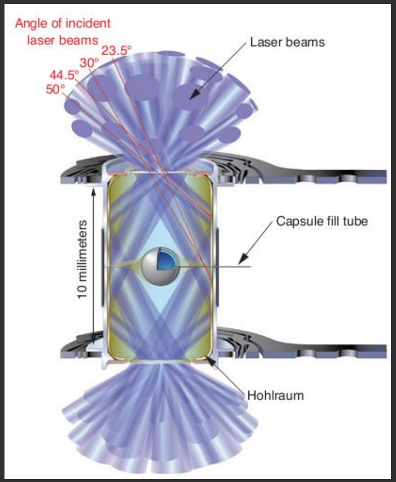
Biggest laser system ever built

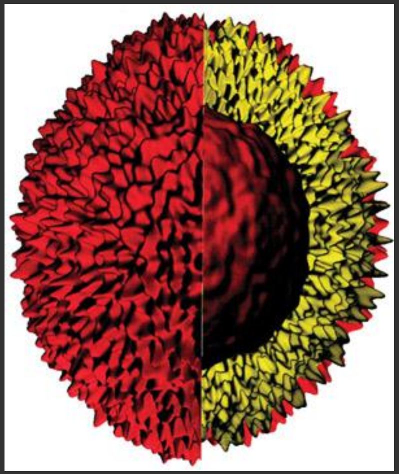
Has been operating since 2008 – ignition campaign began 2010

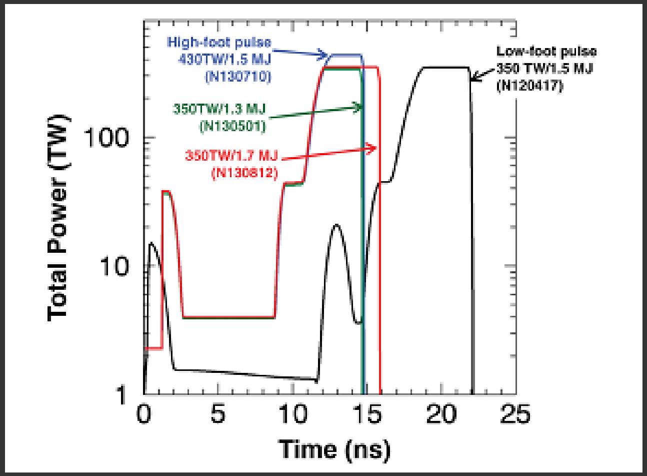
Produced record breaking numbers of neutrons

My friends are clever!

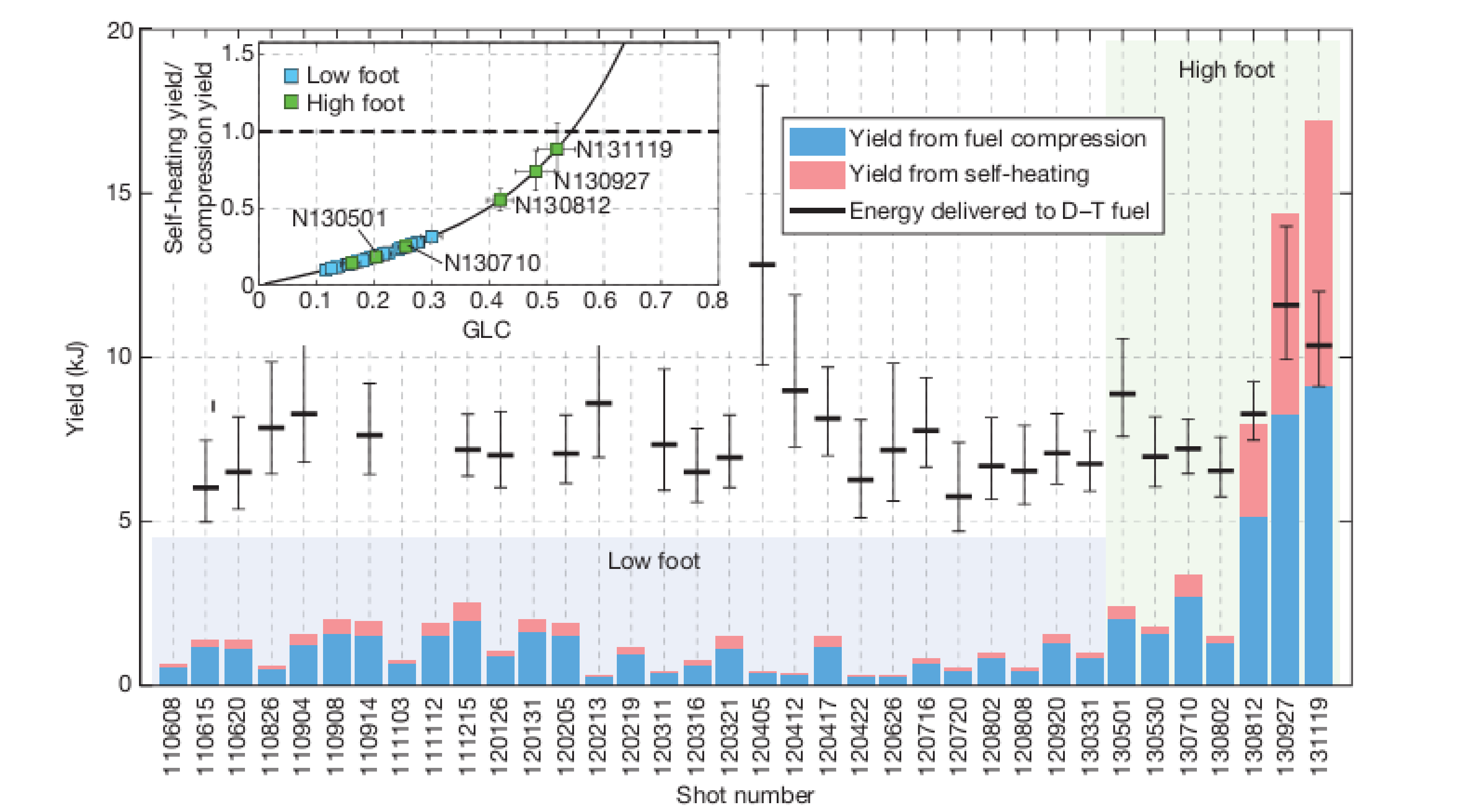








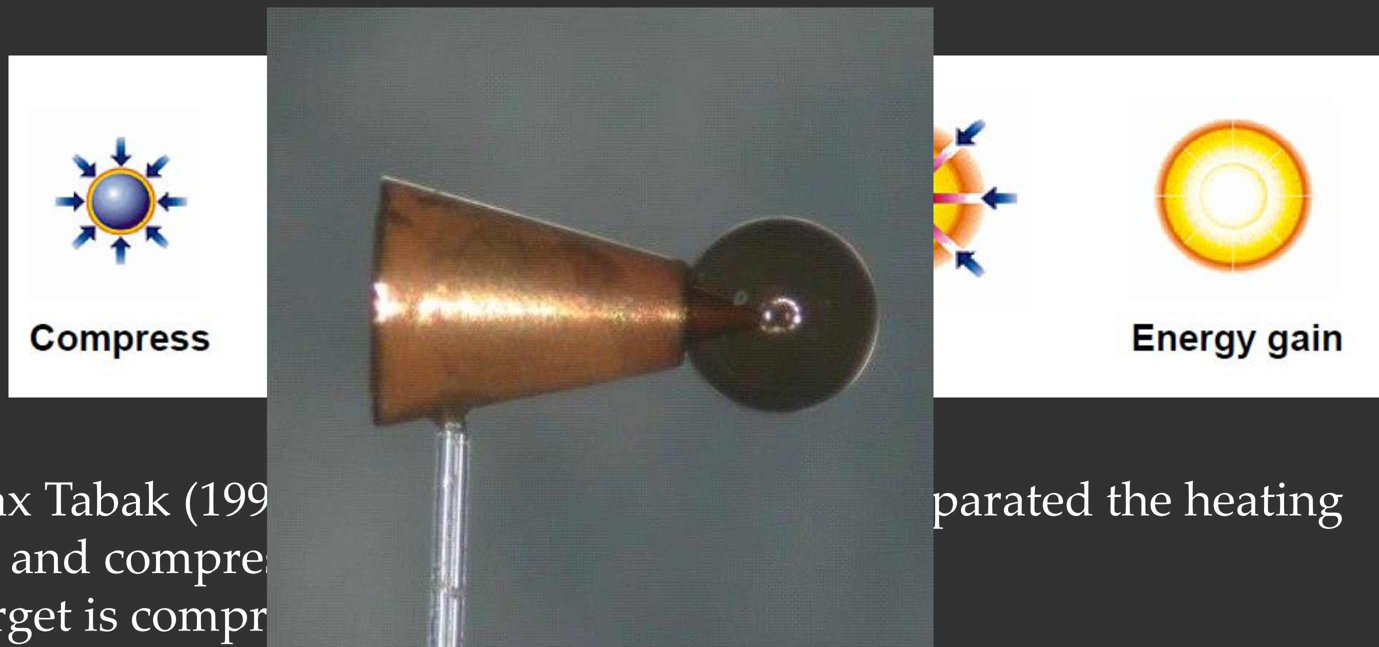
Where are we at?



O. Hurricane et. Al. , Nature 506, 343, 2014

UNIVERSITY of York

Fast ignition



Max Tabak (199 … parated the heating
and compre…

Target is compr…

A high intensity channelling pulse bores a hole through the corona
towards the core

A second ultra intense pulse produces hot electrons with deposit
energy at the core and raise the fuel to fusion temperatures

Getting fundamental

Absorption Physics

How is the laser absorbed?
Do we even understand absorption?

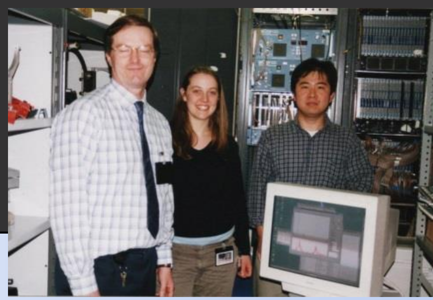
Electron transport

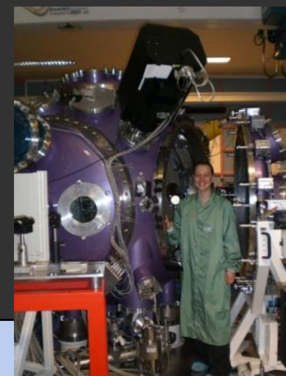
How does the beam propagate?
How does an electron beam stop in dense plasma?
How/Why does the beam diverge?

Electron beam properties

What does the beam look like?
What is the electron energy distribution?

My timeline

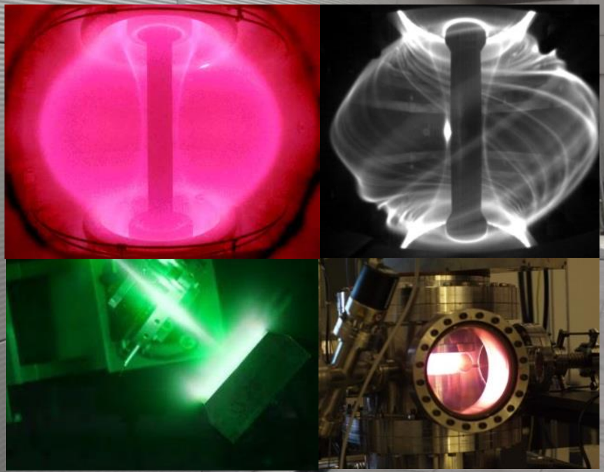




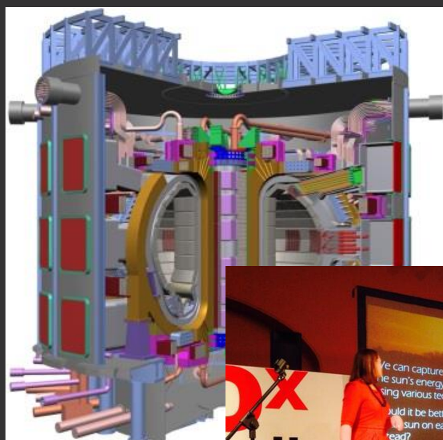
2001 2005 2012 2015

York Plasma Institute

What is the York Plasma Institute?
The York Plasma Institute, within the Department of Physics, is a £3.7M collaboration between the Engineering and Physical Sciences Research Council and the University of York



A jaunt into the world of innovations



Internal facing
Engagement activities for the YPI –
Low temperature, laser-plasma, MCF
IP / commercialisation assistance

Increasing industrial input and skills training into Doctoral Training Network and our undergraduate programme

External facing
IFE Network coordinator - Network industrial engagement activities
Assistance to UK plc to win contracts from ITER through F4E

What does my job look like now?

Industry engagement

Teaching

Research

Some reflections

Don't worry if you don't know exactly what you want to do

- I only got into this field because I liked optics and wanted to mess about with lasers for a bit

Be open minded – at least a little

- You might have experiences you would not have imagined or thought of
- Accept that your path may not always be clear

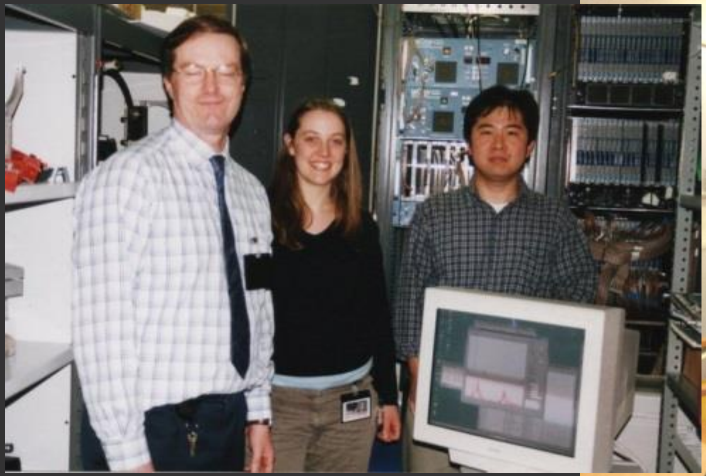
Challenge yourself

- Analyse the situation – do I think I'm not good enough? Why shouldn't I go for it?

Allies are important

My supervisor championed me all the way though my PhD

- find an ally/mentor that will fight your corner.



Fusion training at York

- Run a doctoral training network since 2009
- Made a full EPSRC CDT in 2012
- Renewed for a further 5 intakes in 2014

- Train students in plasmas and materials physics relevant to fusion energy
- Will train a further 77 students in the next 5 intakes

MANCHESTER 1824
The University of Manchester

FCDT
FUSION CENTRE FOR DOCTORAL TRAINING

Durham University

UNIVERSITY OF OXFORD

UNIVERSITY OF LIVERPOOL