HiPER Key Facts

What is HiPER?

- HiPER stands for **Hi**gh **P**ower laser **E**nergy **R**esearch facility
- HiPER is being designed to demonstrate the feasibility of laser driven fusion as a future energy source
- It will also enable the investigation of the science of truly extreme conditions – accessing regimes which cannot be produced elsewhere on Earth (temperatures of hundreds of millions of degrees, billion atmosphere pressures, and enormous electric and magnetic fields).
- HiPER will require major developments in technology, building on the highly successful European capability in this area. In particular, the PETAL laser, located in the Aquitaine region of France, will be a fore-runner to the HiPER facility to address physics and technology issues of strategic relevance for HiPER
- Further information: www.hiper-laser.org, or contact the HiPER Coordinator: Professor Mike Dunne (mike.dunne@stfc.ac.uk)

What is Fusion and why use it?

- Fusion occurs when Deuterium and Tritium (isotopes of Hydrogen) are forced to bond together to create Helium and a very energetic particle called a neutron. This neutron can be captured to heat water to drive a steam turbine. .
- Fusion offers:
  - **Plentiful fuel** (at a scale that can fully meet mankind's long term needs)
  - **Energy Security** (sea water and the Earth's crust are the source of the fuel)
  - **Sufficiently Clean energy** (there are no greenhouse gas emissions, and no long-lived radioactivity)
  - **Safe operation** (there is no stored energy, so 'melt down' or catastrophic failure are impossible)
  - **Complementary solutions** ("magnetic fusion" facilities such as ITER, and "inertial fusion" using lasers)
- The benefits of fusion energy cannot be overstated in a global setting where climate change, pollution, energy security and the ever increasing demand for consumption represent a principal challenge facing mankind. It is not a short term fix, but rather a long-term, sustainable solution that will take a concentrated research and development effort across a range of options to realise its potential.
- HiPER offers a complementary solution to the fusion project known as ITER, which uses magnetic fields to contain the fusion reaction. The scale of the energy problem is such that multiple solutions are demanded. There is great potential for knowledge exchange between the two projects in areas such as material research, diagnostics and the underlying science.
- Fusion has been pursued for over 40 years, with lots of early mistakes with regard to anticipated timescales. Fortunately, both routes to fusion have received many billions of dollars investment, such that their future development path is now clear.

Inertial (laser) driven fusion

- The physics underlying inertial fusion is already proven. This is the approach adopted by Nature – this mechanism powers our Sun and all other stars. Far more importantly, the process of energy production from inertial fusion has already been demonstrated on Earth in a spin-out of the US defence program. Demonstration of net energy from inertial fusion using a laser is now anticipated in the period 2010 to 2012 (on the National Ignition Facility, USA).
- HiPER is designed to move forwards from this landmark demonstration, using an approach which better enables a commercial energy production solution (and a broad-based basic science mission)
- The principle is conceptually similar to a combustion engine – a fuel compression stage and an ignition stage.
- Lasers are used to compress a shell of Deuterium and Tritium fuel to very high density. A very high power laser is then focused into the dense DT fuel, raising it to fusion temperatures (~100 million degrees Celsius).
- The power of these lasers is truly immense: roughly ten thousand times the power in the entire UK national grid! Of course, this power only lasts for a few million millionths of a second and acts like a match to ignite the fusion fuel

The HiPER Science programme

- HiPER will open up entirely new research programmes in a wide range of scientific disciplines, including:

- Astrophysics in the laboratory, including studies of the physics associated with supernovae evolution, proto-stellar jets, planetary nebulae, interacting binary systems, cosmic ray seeding and acceleration, and gamma-ray bursters
- Behaviour of matter in truly extreme conditions (tens of millions of degrees temperature, pressures of billions of atmospheres, and magnetic fields a billion times stronger than that of the Earth)
- *Warm Dense Matter studies* – addressing the principal outstanding regime of material science in which there is no accepted theory (for which HiPER will offer exceptional probing and diagnostic capability). This is of direct relevance to planetary geophysics, tackling uncertainties in the evolution of Earth-like and giant gaseous planets.
- *Turbulence* – how do highly compressible, nonlinear flows transition to turbulence and subsequently evolve? This is one of the few remaining fundamental uncertainties in classical physics.
- *Laser-plasma interaction physics* – including the question of how waves and matter interact under highly nonlinear conditions
- *Production and interaction of relativistic particle beams* – for example, whether macroscopic amounts of relativistic matter can be created (then studied and utilised)
- *Fundamental physics at the strong field limit* – for example, studying the physics of the quantum vacuum, collective and dynamical QED studies such as photon propagation in the early universe, and possibly issues associated with Schwinger pair production and Unruh (Hawking) radiation.

The Timeline

- The project was accepted onto the “European Roadmap” in October 2006, with the UK agreeing to take a leadership role in January 2007.
- HiPER is a consortium of 25 institutions from 11 nations. This includes representation at a national level from 6 countries (Czech Republic, France, Greece, Italy, Spain, UK), 2 regional governments (Aquitaine and Madrid), multiple international institutions and industry. There are also strong international links to programs in USA, Japan, Republic of Korea, Russia, China and Canada.
- This consortium submitted a proposal for a 3-year “preparatory phase project” to the EC on 2nd May 2007.
- Following positive reviews from the EC in July 2007, the preparatory phase project will run from April 2008 to 2011. This phase will establish the scientific and business case for full-scale development of the HiPER facility.
- This phase is timed to coincide with the anticipated achievement of laser fusion *ignition and energy gain* (on the NIF laser in the USA). As such, future phases can proceed on the basis of demonstrable evidence.
- Construction of the HiPER facility is envisaged to start mid-decade, with operation in the early 2020s.
- The UK is a leading contender to host the HiPER laser facility.