6 Large scale strategic facility development

The step-change in scale from existing academic laser systems to HiPER means that considerable development is needed in the scientific underpinning, in the technology maturity, and in the approach of the community to its research programmes. As a result of the work performed in the 2-year design phase, there is now an outstanding level of coordination, communication and common purpose in the large scale laser community within Europe.

6.1 Existing academic systems in the EU

At present, there are three laser systems within the EU capable of delivering in excess of a kilojoule of energy. These are:

- Vulcan, at the Central Laser Facility (UK)
- LULI-2000, at the Ecole Polytechnique (France)
- PALS, at the Institute of Physics (Czech Republic)

Great use will be made of these facilities as part of the preparation for HiPER, as detailed in the experimental validation programme (see section 8). This will be coupled to fundamental physics analyses and the development of diagnostics and experimental and theoretical techniques at the substantial number of smaller scale facilities (see section 7).

Photos of the Vulcan (left), LULI (middle) and PALS (right) laser facilities.

Vulcan, operated by the STFC Central Laser Facility, is at the time of writing the world's most powerful, most intense laser system, delivering in excess of 1 Petawatt onto a focal spot to create an irradiance of 10^{21} W/cm^2. It also provides a short pulse beam of energy >100 J coupled to a 6-beam long pulse capability. Dedicated access to these facilities has been made available to the HiPER consortium, as part of a 4-way agreement between CLF, LULI, PALS and Laserlab-Europe.

The CNRS and CEA support the operation and development of the *Laboratoire pour l'Utilisation des Lasers Intenses* (LULI) in Paris where some of the most advanced facilities in the world for experimental laser-plasma physics exist. Access to these facilities and the expertise contained therein will also be crucial for risk reduction in the HiPER mission.

It has been agreed between the three French agencies (CEA, CNRS, Region Aquitaine) that all HiPER related activity will be co-ordinated and managed by the *Institut Lasers et Plasmas (ILP)* in Bordeaux. ILP is the coordinating Institute in France for research in lasers and plasmas. It officially represents the associated laboratories working on these subjects from CNRS, CEA, University Bordeaux1 and Ecole Polytechnique.

The *Ministry of Education, Youth and Sports* (MSMT), as a funding agency, are formal partners to the HiPER preparatory phase project. Execution of the Czech participation will be through the *Academy of Sciences of the Czech Republic* (CAS). The CAS operates and develops the *Prague Asterix Laser System* (PALS), which is one of the leading experimental facilities in Europe for laser plasma interactions. Access to this system will be made available for HiPER related work, as discussed above.

Further detail on these systems can be found at:

- Vulcan: http://www.clf.rl.ac.uk/Facilities/vulcan/index.htm
- LULI-2000: http://www.luli.polytechnique.fr/
- PALS: http://www.pals.cas.cz/pals/index.html

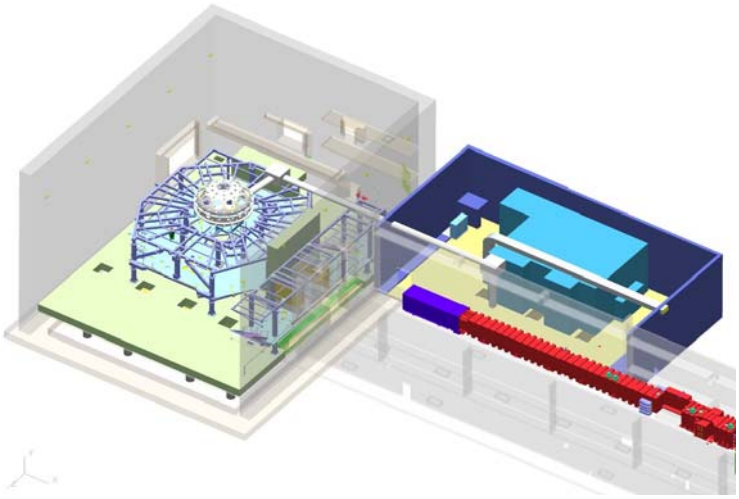
6.2 Ignition scale laser facilities

As described throughout this document, extensive use will also be made of experience from the ignition-class laser systems, NIF and LMJ, with regard to technology options, operational experience, scientific results, and large project issues. These facilities are described in more detail in section 14.

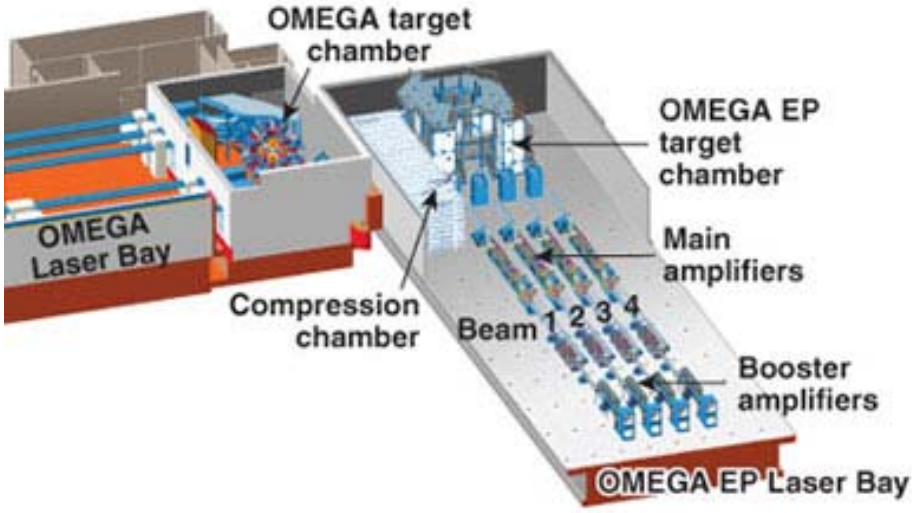
6.3 International, Fast Ignition physics facilities

Coupled to these academic and ignition laser systems, it will be essential over the coming period to make optimum use of the emerging suite of intermediate scale laser systems (at the tens of kilojoule energy level). This is required both to define the most promising route to Fast Ignition, and to ensure that Europe is sufficiently experienced to make good use of HiPER. There are three principal intermediate scale facilities emerging with which the HiPER project will be seeking collaborative experiments:

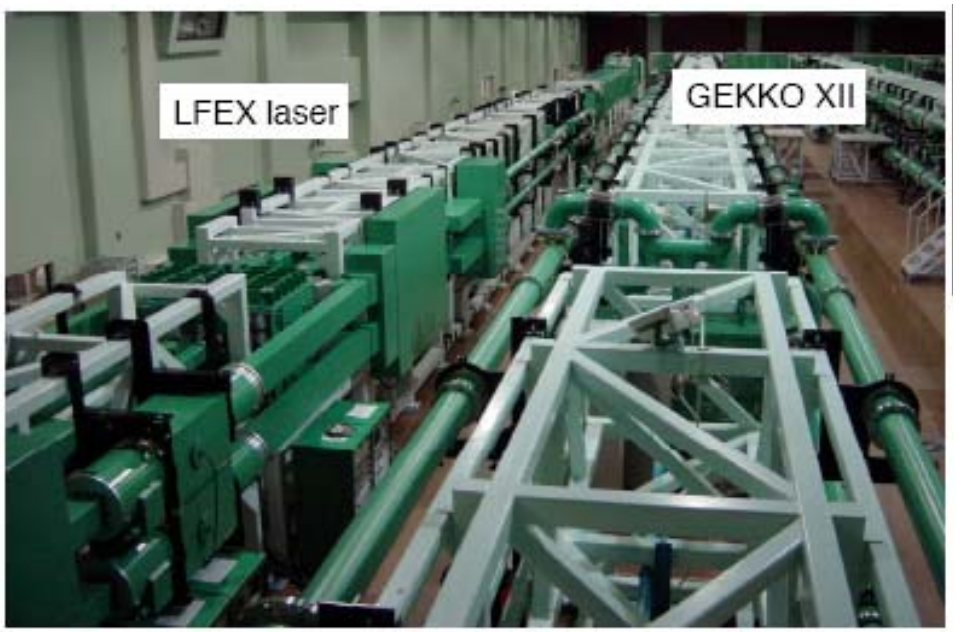
- OMEGA-EP: At the Laboratory for Laser Energetics, University of Rochester, New York, USA. See: http://omegaep.lle.rochester.edu/
- FIREX-I: At the Institute for Laser Engineering, Osaka University, Japan. See: http://www.ile.osaka-u.ac.jp/
- PETAL: At the Centre d'études scientifiques et techniques d'Aquitaine (CESTA), Bordeaux, France. See: http://petal.aquitaine.fr/



The PETAL laser facility, in CESTA, France, will couple a new 3.5 kJ short pulse laser system to the existing 60 kJ LIL laser system.



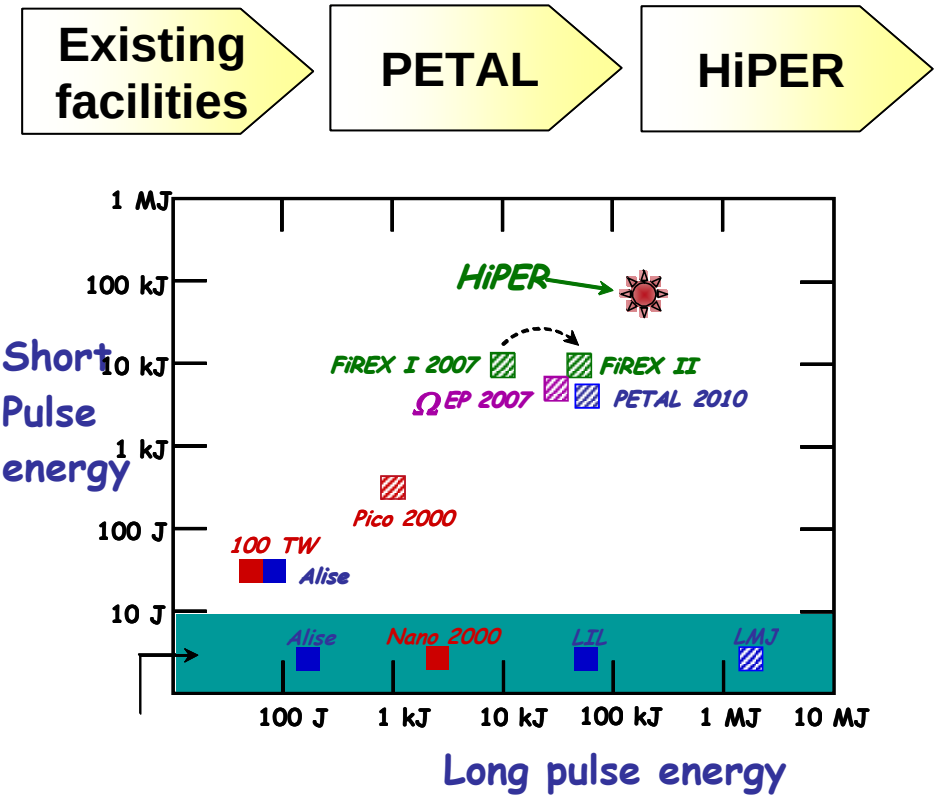
The OMEGA-EP laser will couple two new short pulse beams, 2.6 kJ apiece, with two additional long pulse beams into the existing OMEGA 60-beam 50 kJ implosion facility. This will provide an ideal configuration for studying the physics underpinning Fast Ignition. The facility will progressively come online from 2007-2009.



The FIREX project in Japan will couple a new 10 kJ short pulse (4-beamlet) laser system called LFEX with the existing 12-beam, 10 kJ GEKKO-XII implosion facility. This has been specifically designed to study the physics of fast ignition. A key goal is to achieve sufficient coupling of electron energy into an imploded DT target to raise its temperature to 5 keV. This facility will progressively come online from 2007-2010. Successful achievement of its design goals is required to allow a positive decision on a major upgrade, FIREX-II, which would couple 50 kJ short pulse "ignitor" energy to a 50 kJ implosion system (in the existing laser building).

The CEA has developed near Bordeaux (CEA-CESTA) over the last decade or so the *Ligne d'Intégration Laser* (LIL) and the multi-billion Euro *Laser MégaJoule* (LMJ) systems that are central pillars of its national strategy to advance the Inertial Confinement Fusion concept. It therefore brings to the HiPER project unrivalled expertise within Europe. The HiPER strategy relies heavily on leveraging this expertise and the huge defence programme investment it represents into the civilian arena for the pursuit of fusion energy through the HiPER mission. The CEA's technical and political involvement is substantial and they are formally prepared to make available to HiPER people, information, technology, costs etc that will be crucial to developing HiPER. The CEA also provides an important portal to French industry that has developed most of the technology for LMJ.

Moreover, the local regional funding agency, the *Conseil Régional d'Aquitaine* (CRA) in conjunction with the French government, has recently invested more than 40 M€ in the PETAL enhancement to the LIL system to explore the fast ignition approach to Fusion Energy. CRA as a funding agency is also a formal partner in the HiPER project. Construction of the PETAL facility in the Région Aquitaine represents a very major step towards the realisation of HiPER. It provides a local "stepping stone" that will ensure the project partners are able to tackle the myriad of scientific, technological, operational and organisational issues associated with large scale laser science. Preparation of the HiPER proposal has led to its formal joining together with PETAL under a common strategic plan. The agreed approach is to evolve from existing facilities, to PETAL, to HiPER, with all three tiers playing a major role during the operational phase of HiPER.



In recognising the importance of the PETAL system to the HiPER mission, the CEA and CRA have agreed to the reconfiguration of PETAL system as per the needs of the HiPER project. An international panel of experts has thus recently been appointed to advise on the exact nature of this development.