PETAL: from the laser system to the physical applications

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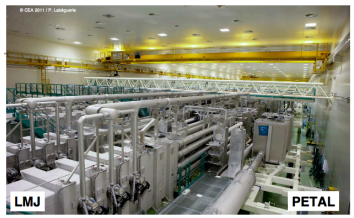
The laser system

PETAL and LMJ amplifier sections



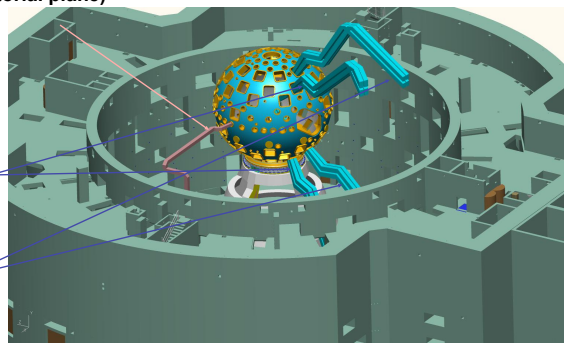
Coupling of PETAL multi-PW beams with LMJ Quads

PETAL	1 Quad LMJ
- Energy * > 3 kJ,	Energy > 30 kJ,
- Wavelength : 1053 nm,	Wavelength : 351 nm,
- Duration 0,5 ps - 10 ps,	Duration a few ns,
- Intensity on target	Intensity on target
- > 10^{20} W/cm^2,	> a few 10^{15} W/cm^2
- Intensity contrast	Energy contrast
(short pulse) : 10^{-7} at -7 ps,	(long pulse) : 10^{-3}

* now limited to 1 kJ because of damage threshold of mirrors used for in vacuum beam transport

"PETAL" stands for "PETawatt Aquitaine Laser", a petawatt laser coupled with LMJ facility for civilian research. The "Région Aquitaine" is the contracting owner of the PETAL facility (budget 54.3 M€). CEA is the project manager and the prime contractor of the PETAL project. Technical and scientific assistance are provided by ILP (Institut Lasers et Plasmas). PETAL is part of the *Pole de compétitivité* "Route des lasers"

PETAL
(in the equatorial plane)



Coupling PETAL-LMJ
Configuration expected in 2015

PETAL will act as a demonstrator of physics and laser technology for the HiPER programme

LINKS with HiPER:

- PETAL is a key element in academic access to LMJ
- PETAL will allow for significant experiment in the domain of Fast Ignition (allowing to inject up to several hundreds J of fast electrons into the target)
- PETAL will allow probing of LMJ implosion in PDD experiments related to Shock Ignition

The PETAL+ Project
Diagnostics realisation for PETAL

Budget 9.3 M€

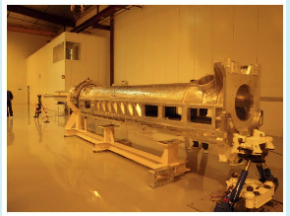
Realisation of Diagnostic Insertion Systems (SID)
The SID for PETAL will be different from the standard LMJ SID because it will require extraction of detector components (e.g.: CR39 and RCF films, IP detectors, and other passive detectors).

Realisation of 3 first plasma diagnostics: Proton Spectrometer, Electron Spectrometer, X-ray spectrometer. Detection will be mostly based on passive removable detectors (IP, films,…) to avoid effects of large EMP induced by PETAL pulse and perturbations form large particle fluxes. They will also be designed to work in a nuclear environment (T pollution, activation, …).

The proton spectrometer:
- Proton spectral range: 0.1 - 200 MeV
- Thomson Parabola to distinguish the charge states
- Signal dynamics 10^5
- Observation field on target: 1 - 10 mm
- Transversal spatial resolution: 10 - 100 µm

The electron spectrometer:
- Electron spectral range: 300 keV - 50 MeV
- Resolution 5%-
- Will use permanent magnets and Imaging Plates
- A detection based on activation measurements (extraction of sample and counting rate) will allow a precise determination of the total electron number

The X-ray spectrometer:
- X-ray spectral range: 5 keV- 120 keV
- Resolution: 1/300
- crystal in transmission (Laue diffraction, Cauchois geometry)
- Detection with Imaging Plates



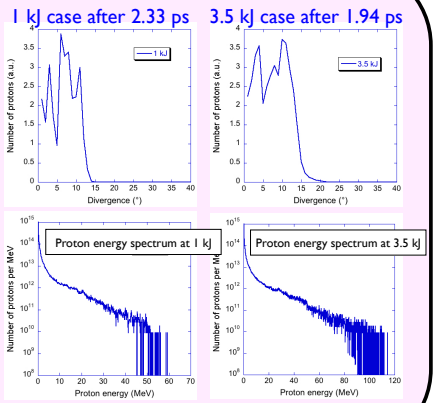
Example of insertion system (SID) on LMJ interaction chamber

Physics with PETAL: Phase 0

Characterization of PETAL performances / diagnostics tools / secondary sources

Estimation of Proton emission from a 10-µm plastic target irradiated with PETAL from 2D PIC simulations using the code PICLS
Proton divergence distribution for protons with an energy > 40 MeV in the forward direction

(Comparable to the 50 MeV obtained on Omega EP by K. Flippo et al. with 1kJ but with a longer pulse duration)



Physics with PETAL: Phase 1

- **PETAL for fast ignition experiments (generation of electron and/or ion beams, study of fast electron propagation)**
- **PETAL to study secondary sources (protons, X and γ rays, …)**
- **PETAL as a back lighter of LMJ**
  - **Probe dense states created with shock compression or adiabatic compression of samples with LMJ beams (Direct measurements of density, shock, fluid velocity using proton radiography and hard X-ray radiography)**
  - **Use proton and hard X-ray backlighting to probe implosion and uniformity compression of targets imploded by LMJ (Shock Ignition approach to ICF, Polar Direct Drive)**
  - **Use protons to measure magnetic fields related to jet formation (Laboratory Astrophysics)**
- **PETAL as a physics tool**
  - **Create WDM states by short-pulse ("isochoric") heating LMJ can be used as a time-continuous backlighter**
  - **Create intense proton / ion beams ans study their propagation (stopping power) in WDM samples created with LMJ**
  - **etc. etc. …**