

Some views on the European HEDP-UHI laser and scientific landscape

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- The European key HEDP laser facility: LMJ-PETAL
- The first academic LMJ-PETAL experiments
- Structuring the European laser continuum: LASERLAB-Europe
- Structuring the ICF-related research: EUROfusion
- The Extreme Light Infrastructures
- The APOLLON laser facility and its scientific program

LMJ-PETAL is the European & French flagship for High Energy Density Physics

Laser MegaJoule (LMJ)



progressive ramp-up in energy & in diagnostic capabilities; 150 shots (1/day) on target already delivered

Petawatt Aquitaine Laser (PETAL)



1,2 PW (846J/700fs) obtained in 2015
~2 PW reachable next year (570fs)

Attractive academic user program

25 proposals submitted through calls of proposals,
6 accepted
a well-attended 1st user meeting in October

next call: 2019

user guide & information on: <http://www-lmj.cea.fr/en/ForUsers.htm>

from end 2016



end 2018



2 nd config.	3 rd	4 th	5 th	6 th
4 quads+PW 60 kJ	10 quads+PW 150 kJ	14-18 quads+PW 250 - 320 kJ	22-40 quads+PW 0,53 - 1 MJ	44 quads+PW 1,5 MJ
5+5*	8+5*	15+5*	22+5*	>22+5*

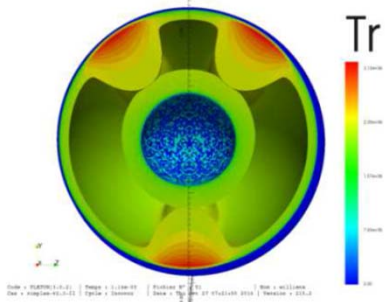
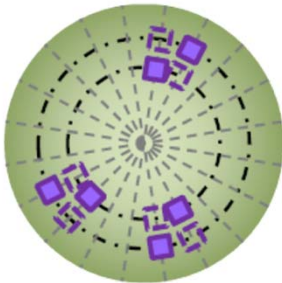
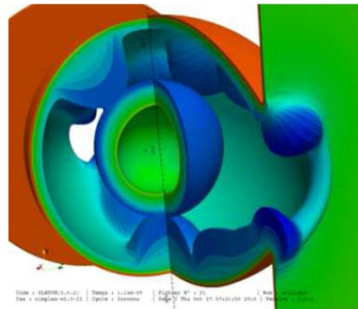
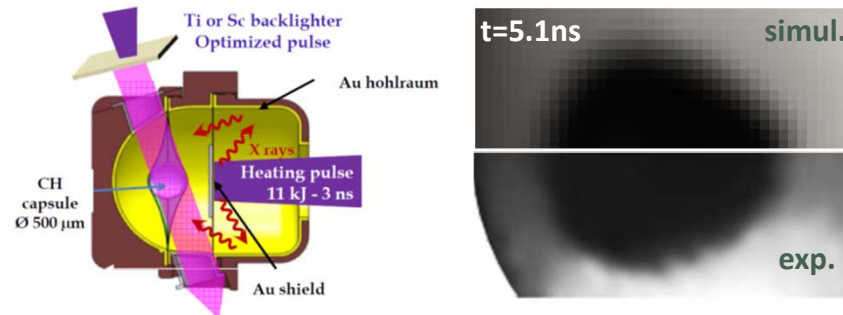


by courtesy of J.-L. Miquel

A first fusion milestone will be reached in 2019



conclusive preliminary study of the influence of an anisotropic drive distribution on an imploded capsule shape



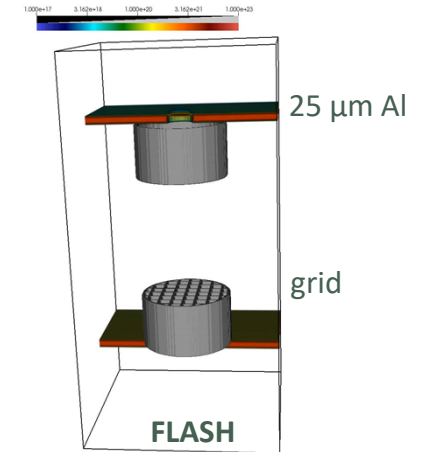
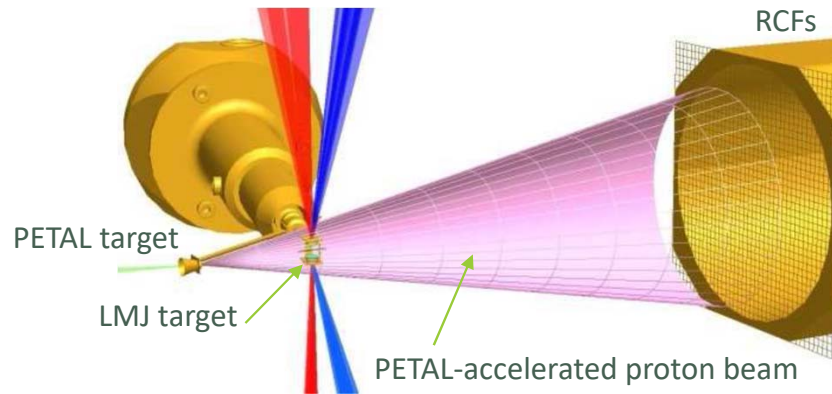
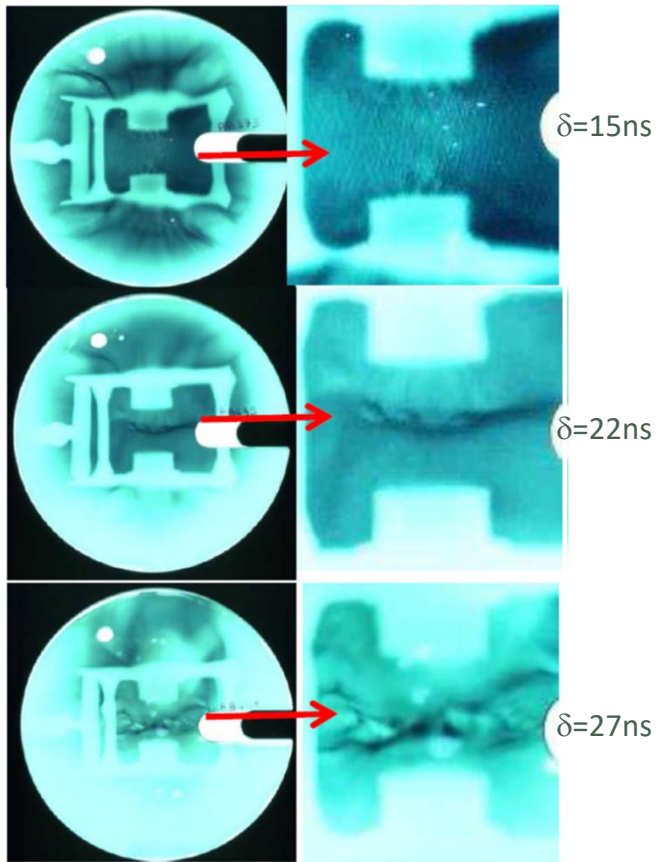
D₂-filled indirectly-driven “symmetric” capsule implosions to be driven in 2019 with 12 quads

high low-mode non-uniformities → relevant benchmark for CEA 3D simulations

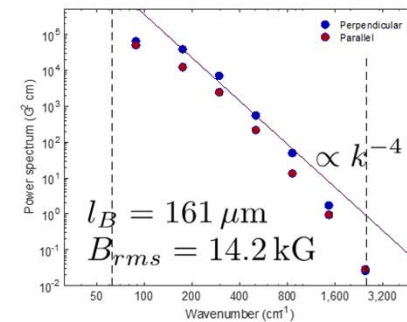
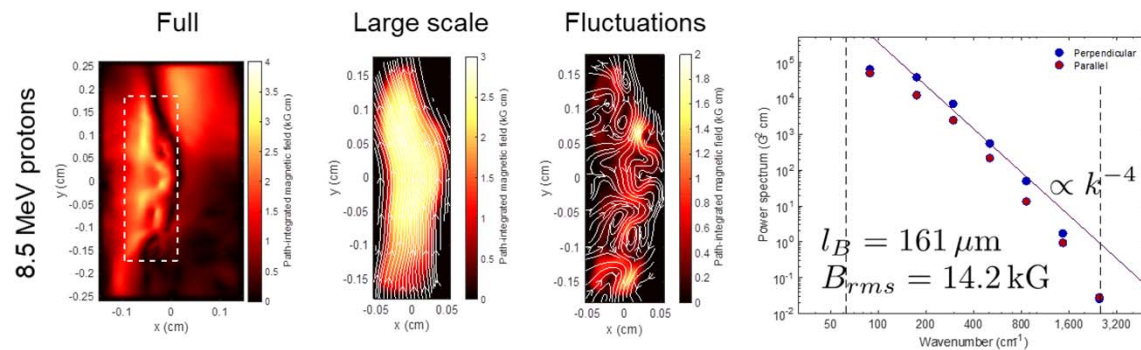
50 years after the first fusion neutrons produced in 1969 with the CEA L5 laser, D₂ fusion neutrons will be produced on LMJ!

Astrophysically-relevant turbulence & B-field generation

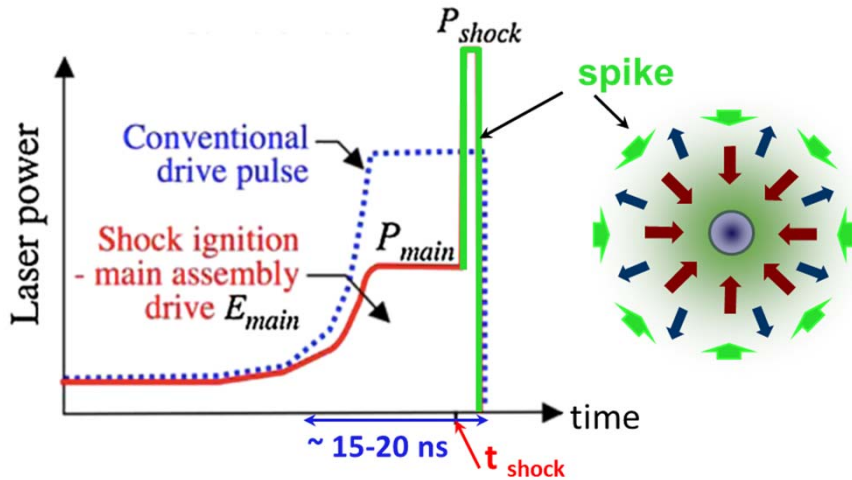
was explored in the first LMJ-PETAL academic experiment



evolution of B fields during flow collision measured thanks to proton radiography
magnetic energy power spectrum agrees with supersonic turbulence modeling



The 2nd one will tackle IFE-relevant shock ignition physics issues



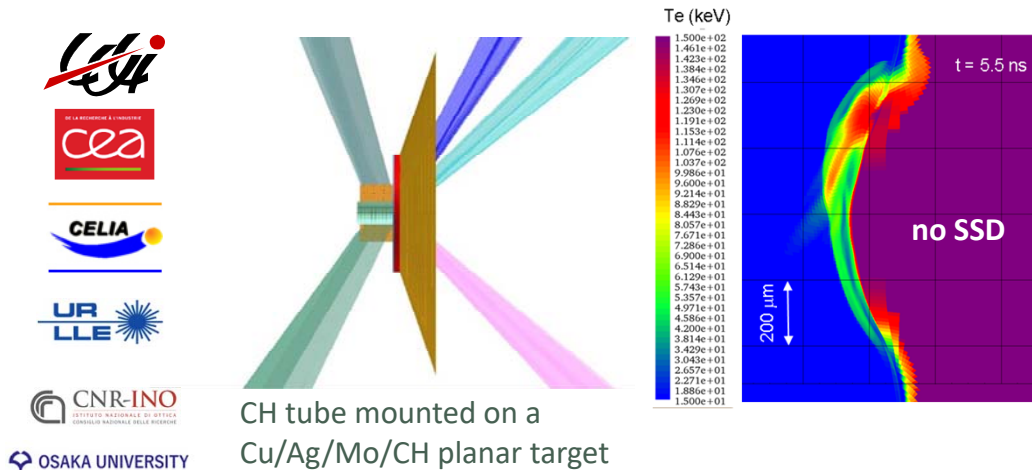
generation of a strong enough (300-400 Mbars) shock through a large corona?

at the required spike intensity ($>10^{15}$ W/cm²), will parametric instabilities and induced hot electron production be detrimental, or not?

CHIC simulations of the planned LMJ experiment show

- w/o SSD: hot electron production from SRS (45 keV) & TPD (90 keV) whose deposition leads to an asymmetric shock wave
- with SSD (no hot electrons): ablation pressure is reduced (~ -40 mbars) as well as the shock velocity

5 diagnostics to be implemented to measure laser energy balance, hot electron temperature distribution & shock strength and velocity



CH tube mounted on a Cu/Ag/Mo/CH planar target



next: April 2019

by courtesy of S. Baton

The success of experiments on Very-Large-Scale Infrastructures

rest on preparatory experiments on mid-scale facilities

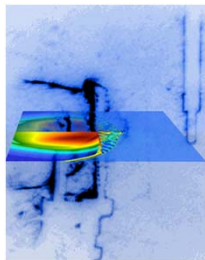
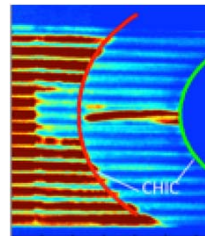
generation & x-ray radiography
of a strong shock (40 Mbars)

2010-2013



record shock pressure
(90 Mbars) in planar geometry

2014



validation of the radiography
set-up & analysis

2018



200 Mbars?
2019-2020

2010-2012
seeding B-fields
by Battery effects

2012-2014
turbulent amplification

2016-2017
dynamical equipartition
between fluid motions and B-field
B-field reconstruction algorithm validation

2017
supersonic turbulence

by courtesy of G. Gregori & S. Baton

The European laser continuum is structured through LASERLAB-Europe



current contract: from the 1st Dec. 2015, for 4 years

22 Access providers

at least 3005 access days provided on 289 projects
and for 676 users, incl. non-EU researchers

➔ 19 non-EU projects, representing ~12% of
the access provision

Canada, China, India Japan, Russia, USA

next contract under préparation (submission: March 2019)

↪ global collaboration encouraged: Asian Intense Laser Network?

more information on <https://www.laserlab-europe.eu/transnational-access>

As for MFE, the IFE community is coordinated thanks to EUROfusion


through keep-in-touch & dedicated projects

Mission 1: acquiring new insights into the basics of ignition physics

- plasma atomic physics  & radiation sources
- laser-plasma interaction
- hydrodynamics & implosion

Mission 2: towards demonstration of shock ignition on MJ-class laser facilities

Mission 3: testing the feasibility of other alternative schemes

- electron-driven fast ignition 
- ion-driven fast ignition; impact ignition
- aneutronic fusion
- auxiliary heating

Mission 4: developing key IFE technologies

- laser & target technologies
- diagnostics
- IFE materials & reactor technologies



2019-2020: proposals submitted in August

talk LPL-7 by P. Norreys

The Ultra-High-Intensity landscape is also evolving

with the  ESFRI project initiated by G. Mourou



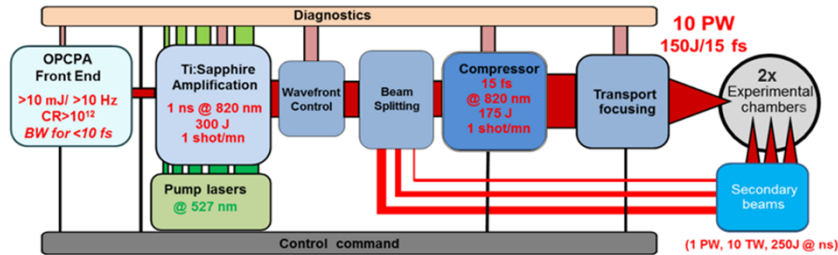
3 very-large-scale infrastructures to investigate light-matter interactions at highest intensities and shortest time scales

- ELI-NP: an unique combination of very intense laser ($I=10^{23-24}$ W/cm²) and γ beams
↳ nuclear physics
- ELI-Beamlines: short-pulse secondary sources of radiation and particles
↳ multidisciplinary applications
- ELI-ALPS: ultrashort from THz to x-ray light sources at high repetition rate
↳ extremely fast (as) electron dynamics in atoms, molecules, plasmas and solids

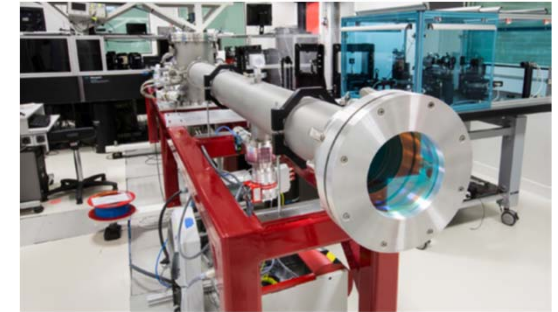
a large variety of applications to be prepared on mid-scale facilities

Apollon soon open to the user community within LASERLAB-Europe ...

4 independent laser beams based on an OPCPA front-end and Ti:Sa amplifications stages



- * F1: up to 10 PW (150J/15fs)
- * F2: 1 PW (15J/15fs)
- * creation: up to 250 J uncompressed
- * probe: 10 TW (150mJ/15fs)



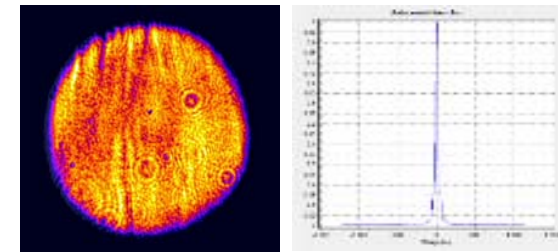
2 independent radio-protected experimental areas

- HE1 (SFA) for LPI with solid targets at a few 10^{21} W/cm² (f/2.5) for proton, ion and x-ray radiation secondary beam generation
- HE2 (LFA) for particle acceleration (electrons) using long focal length focusing optics

qualification @ 1 PW 30.5 J / 24.4 fs \pm 0.5 fs

2nd user meeting Spring 2019

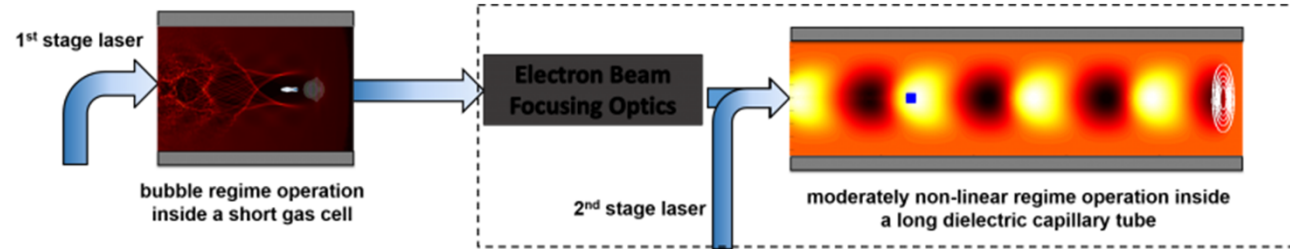
1st commissioning experiments mid-2019



... on various research topics

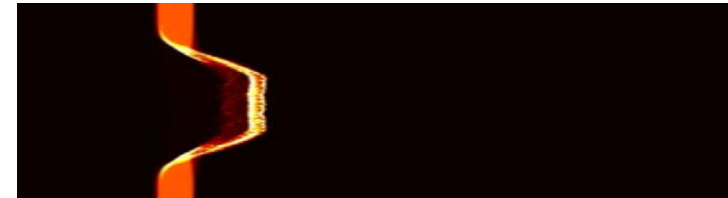
Electron acceleration

- single- & multi-stage electron acceleration
- induced x-ray production (FEL-type or betatron)



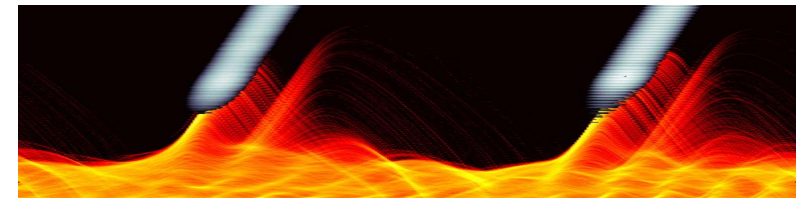
Ion acceleration

- breaking the 100 MeV limit
- advanced TNSA & radiation pressure acceleration mechanisms
- warm dense matter physics, laboratory relativistic astrophysics



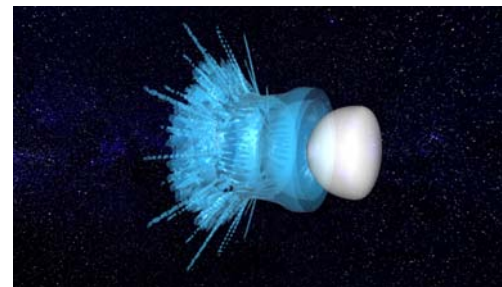
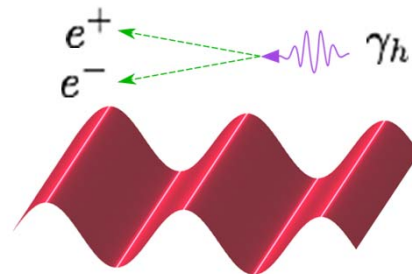
X-ray sources

- plasma mirror & HHG from solid targets



High-field physics

- QED effects in laser-plasma interaction
- high-energy γ & positron generation



Smilei)

a multi-physics, collaborative,
open-source, HPC-oriented
simulation tool

2nd training workshop: early 2019