Organization of the project and research groups involved

The project is based on an extended network of collaborations, including the groups, which in Europe have already contributed to DD and SI research. The coordination of the work will be assured through the constant contact of the project PI and the leaders of the groups, and through the organization of "internet" meetings involving group leaders and WP leaders (one every 3 months, duration half a day). Specific "physical" workshops of 2-3 days on selected important topics will be organized whenever needed (these workshops may for instance address topics like code validation, development of diagnostics, final analysis of experimental results, final editing of proposals for experiments). General meetings of the researchers involved in the project will be organized on months 6, 18 and 30. A closing meeting will be organized on month 36. This will also include the discussion about future continuation of the work.

The groups involved in the present project are listed below, including the group leaders, individuals, and the expertise and the main effort realized by each group.
Altogether, these teams represent the best competences in Europe in the field of inertial fusion and bring together the necessary expertise to advance the experimental work (in European "intermediate" laser facilities and also in very large facilities like NIF, LMJ, SGIII, Omega), to progress in theory and simulations, to develop innovative diagnosis. The collaborative network extends over US, Japan and China. It is also important to notice that the groups of the EUROFusion ER project CfP-AWP17-IFE StarkZee (2017-2018), have now joined our project, increasing our critical mass and ability to propose innovative subjects. Concerning capacity of attracting and retaining experts, we are trying at the moment to hire Wolfgang Theobald from LLE Rochester at the University of Bordeaux, which would certainly strengthen our collaboration with Rochester even more.

At the end, we also list some groups from outside Europe which wished to be inlcuded asexternal collaborators of our proposal.

LIST OF CONSORTIUM MEMBERS AND EXTERNAL COLLABORATING GROUPS

FRANCE

1) CELIA, Université de Bordeaux, Talence - Group Leader: Dimitri Batani
Researchers involved: Philippe Nicolai, Didier Raffestin, Arnaud Colaitis, Alexis Casner, Olena Tourianska, Alessandro Tentori, Vladimir Tikhonchuk, Joao Santos, Guillaume Duchateau, Diego Viala

The group is involved in the study of all the aspects of SI, theoretical and experimental. The main facilities include the hydrocode CHIC at the numerical level, the short-pulse high-intensity laser Eclipse, and the possibility of access to the LMJ/PETAL laser facility on the CEA/CESTA site near Bordeaux (we collaborate with CESTA on several projects on diagnostics development). During our previous ER-IFE project, CHIC has been updated including a self-consistent description of parametric instabilities, hot electron generation and the effects of hot electron deposition on hydrodynamics. The group is regularly accessing Large Scale Laser facilities in Europe (PALS, Phelix, LULI, Vulcan) and outside Europe: Omega at the University of Rochester and Gekko/LFEX at the University of Osaka.
In 2020 Riccardo Betti and Wolfgang Theobald from LLE Rochester and Alexis Casner and Xavier Ribeyre from CELIA have been awarded the joint APS-EPS Landau-Spitzer prize "for major advancements of the shock ignition concept through collaborative experimental and simulation efforts in inertial confinement fusion research".
Wolfgang Theobald from LLE is currently looking for a position at CELIA.

2) PIIM, Université de Marseille, Marseille - Group Leader: Sandrine Ferri
Researchers involved: Sandrine Ferri, Olivier Peyrusse, Joël Rosato, Annette Calisti

The PIIM partner has a long and internationally recognized expertise in modeling and code development for plasma spectroscopy. In particular, the PIIM group develops and maintains models and codes to calculate: -atomic structure, -population of the ionic species present in a plasma, -spectral line profile emitted by multi-electron emitters in dense and magnetized plasmas,-redistribution functions necessary in radiative transfer calculations, and to model by using a homemade classical molecular dynamics simulation code suite, the environment of emitter in dense plasmas. Thanks to the previous CfP-AWP17-IFE StarkZee project, the PIIM group has developed a fast and universal Stark-Zeeman line shape code, PPP-B, that accounts for B-field dependent atomic physics (code MASC). It has also developed numerical simulations using classical molecular dynamics simulation technique to characterize the plasma environment of the radiator. The latter will be improved to investigate the effect of the helical trajectories of the charged particles around the B-field lines of strength.

3) LULI, Ecole Polytechnique, Palaiseau - Group Leader: Bruno Albertazzi
Researchers involved: Bruno Albertazzi

LULI has a long and consolidated experience in laser-plasma interaction, physics of laser-driven shock waves, physics of inertial fusion. LULI is home of the lasers LULI2000, ELFIE and Apollon.
The scientific framework of our group is mainly related to High Energy Density Physics (HEDP). We are especially focused on the experimental aspects of HEDP and how reproduce and study such extreme conditions in the laboratory. To do that, we perform experiments all around the world (LULI and LMJ/PETAL in Europe, SACLA (XFEL facility) and GEKKO in Japan, NIF in the United States). In parallel, we developed an experimental technique allowing us to couple high magnetic field (up to 40 T) with high power lasers. This makes us one of the leader worldwide to investigate HEDP problematic where magnetic field can influence the dynamics of plasmas.

ITALY

4) **University of Rome “La Sapienza”, Rome -** Group Leader: Stefano Atzeni
Researchers involved: Angelo Schiavi

The Rome-Sapienza group has specific expertise and tools to contribute to all the objectives of the project. In particular, the group has also lead several experiments in the framework of our previous ER EUROfusion project, in particular on the effects of hot electrons on laser-generated shock waves, and perform full-scale simulations of (nearly) symmetrically compressed, bipolarly shocked targets. Available Resources include the 2D nuclear-radiation-hydrodynamics DUED.

5) Politecnico di Milano, Milano - Group Leader: Matteo Passoni
Researchers involved: Matteo Passoni

Matteo Passoni is involved in the study of laser-plasma interaction, theoretical and experimental. The main subjects are the investigation of laser-plasma interaction in the near-critical regime and/or with nanostructured plasmas, laser-driven particle acceleration and their applications, parametric instabilities. The adopted theoretical methods involve both analytical modeling and PIC simulations (with different PIC codes). On the experimental side, he conceived and developed methods to produce nanostructured materials for laser-plasma interaction with PVD techniques, as well as experiments on laser-driven ion acceleration and its applications. He is scientific responsible of Eurofusion activities and of the ERC ENSURE and INTER projects at Politecnico di Milano.

6) INO, CNR, Pisa - Group Leader: Gabriele Cristoforetti
Researchers Involved: Petra Koester, Leonida Gizzi

The researchers involved in the project are associated to the Intense Laser Irradiation Laboratory (ILIL), a sub-PW laser installation at CNR-INO.

The group at ILIL has an established background in laser-plasma interaction with proven skills in the experimental characterization of absorption mechanisms including parametric instabilities (SRS, SBS, TPD) in the context of ICF and Shock Ignition physics. The group has a consolidated experience in the development of plasma diagnostics based on plasma emission in the optical and X-ray range, and the characterization of hot electrons through K-□ and Bremsstrahlung emission, hot electrons transport in solids and in Monte Carlo simulations.
The group has participated with leading roles in European Projects (HiPER, ENR-IFE, ELI) and is a long term user of medium-large scale facilities (PALS, Vulcan, Gemini, Gekko, LMJ).

7) Università di Milano Bicocca, Milano - Group Leader: Massimo Nocente
Researchers involved: Giuseppe Gorini, Croci Gabriele

The group in Milano-Bicocca has a long experience in plasma diagnostics for MCF and, more recently, for ICF. In the framework of the present project, we want to develop and test a detector based on the Cherenkov effect for measurements of high energy gamma-rays born from fusion reactions in plasmas. The measurement of 17 MeV gamma-rays born from the D+T -> ^{5}He+ g reaction is being proposed as an alternative method to determine the fusion power in magnetically confined fusion (MCF) plasmas. The reaction occurs together with the main D+T -> ^{4}He+n fusion reaction in deuterium-tritium plasmas, but with a comparatively much lower probability, at a level between 10^{-4} and 10^{-5} depending on the plasma conditions. In inertially confined fusion plasmas, the 17 MeV emission is one of the preferential methods to determine the time resolved yield from high gain implosions as, unlike 14 MeV neutrons, 17 MeV gamma-rays do not experience scattering in the dense plasma medium and their yield is thus representative of the number of fusion reactions per second that occur. The successful test of this detector will be of relevance for MCF too.

8) ENEA - Centro Ricerche Frascati, Frascati - Group Leader: Mattia Cipriani
Researchers involved: Pierluigi Andreoli, Giuseppe Cristofari, Sarah Bollanti, Francesco Flora, Danilo Pacella, Gerardo Claps, Francesco Cordella

The group works on several aspects of Inertial Confinement Fusion, both experimentally and theoretically. It maintains and uses the ABC Nd:phosphate glass laser facility (2 beams, 100 J per beam, 1054 nm / 527 nm wavelength, 3 ns, up to 10^{15} W/cm^{2} per beam) equipped with a wide number of diagnostics routinely used for every shots. In the last years, the group has frequently had access to Large Scale Laser Facilities. In particular, in Europe: PALS, Phelix, LULI, Vulcan Petawatt; outside Europe: Texas Petawatt at the University of Texas at Austin and Gekko XII at the University of Osaka).
Among the main research topics we mention the studies of the Direct Drive Uniformity, by using porous materials and by preheating the target before of the main pulse (hybrid approach), the low-yield fusion reactions such as H-11B and the emission of radiofrequency-microwave radiation from the laser-matter interaction. The development and testing of diagnostics for particle and electromagnetic radiation (ionizing and not-ionizing) coming from the laser-matter interaction is one historical and hot topic of research of the group, thanks also to the large experience matured in developing ionizing radiation diagnostics for magnetic fusion plasmas.

SPAIN
9) Universidad de Las Palmas de Gran Canaria (ULPGC) - Group Leader: Ricardo Florido
Researchers involved: Ricardo Florido

The group interests and skills focus on the modelling of NLTE atomic kinetics, radiative properties and X-ray spectroscopy of high energy density plasmas. We developed the collisional-radiative model ABAKO, recently improved to account for plasma mixtures and high-density effects. In 2019, we hosted the 11th NLTE Code Comparison Workshop. The group has been involved in OMEGA direct-drive implosion experiments --led by R. Mancini, UNR (USA)-- and performed the first spectroscopic diagnosis of core conditions from SI implosions. We are part of the team –led by colleagues from UCSD (USA) and CELIA (France)— that soon will conduct magnetized cylindrical implosion experiments on OMEGA. During our previous ER-IFE project, we made progress on the theoretical framework for describing the K-a emission induced by suprathermal electrons from the perspective of detailed atomic-physics, including the impact of continuum-lowering models and degeneracy effects in warm dense plasmas.

10) USAL Salamanca - Group Leader: Luca Volpe
Researchers involved: Luca Volpe

Luca Volpe is leading the laser-plasma chair at the University of Salamanca joined with the Centro de Laseres Pulsados and is chairing the BP&IF section of EPS. Luca Volpe has long experience in plasma diagnostics for ICF and participated to several experimental campaign related to laser-fusion in many laboratories in EU and abroad among which VULCAN, PALS, Phelix, Gekko/LFEX ORION and LULI where he performed an experiment to study fast electron transport for fusion.
Luca Volpe is expert in charged particle transport in extreme states of matter and related diagnostic techniques such x-ray and proton radiography of WDM.
Luca Volpe is responsible for the user access in the PW system VEGA at the CLPU where he also performed experimental campaigns to study proton stopping power in WDM.

11) Polytechnic University of Madrid - Group Leader: Javier Honrubia
Researchers involved: Rafael Ramis, Vincenzo Rosciano

The group of the School of Aerospace Engineering at the UPM has a broad experience in theory and numerical simulations of IFE targets. The group has worked on fast ignition of fusion targets, implosions of direct-drive magnetized targets, and guiding of fast electrons by external magnetic fields relevant for shock ignition (SI) and fast ignition. The group contribution will be focused on simulations of i) hot electron generation and transport in direct-drive capsules at SI intensities; ii) electron and ion driven fast ignition of fusion targets, and iii) simulations of magnetized implosions of direct-drive targets, including fuel ignition. Available resources include i) multidimensional radiation-hydrodynamic codes, including 3D MHD; ii) 2D/3D PIC codes; and iii) a 2D/3D fast electron transport code, accounting for external and self-generated fields.

12) University of Valladolid - Group Leader: Marco Gigosos
Researchers involved: Marco Gigosos

We have more than 40 years of accumulated experience on plasma diagnosis and proven expertise on Stark-broadening calculations. Recently, we have improved our molecular dynamics code (DinMol) to account for strong coupling and thermal imbalance, and also enabling the computation of complex Stark-Zeeman line shapes. These calculations can be used for improving the theory and benchmarking of analytical models. Our line shapes calculation of K-shell transitions have been used for the diagnosis OMEGA implosion cores. We are part of the team –led by colleagues from UCSD (USA) and CELIA (France)— that soon will conduct magnetized cylindrical implosion experiments on OMEGA.

13) Instituto Fusión Nuclear "Guillermo Velarde" - Group Leader: Antonio Rivera
Researchers involved: Eduardo Oliva

Official Research Institute of the Madrid Government, in the frame of UPM, since 1982 (BOE nº 73/26-3-1982) as Advisor to Presidency of Government in all Nuclear Affairs. It has groups in three Universities: UPM, UNED and ULPGC. It has been and is mainly devoted to Inertial Confinement Fusion research as energy source in areas of laser-ion interaction with plasma, target design and manufacturing; ICF reactors design including neutronics and safety processes; Materials under irradiation. In addition, it has been a very active collaborator in EU Fusion Technology in general, ITER in particular through its group in UNED University. Partitioning and Transmutation by Accelerator Driven Systems and Neutron (Radiation) Sources based in Spallation has been also part of its research. It is composed actually by 30 Professors, 7 Post-Docs, 1 Specially Ministry granted *"Beatriz Galindo"* Guest Professor, 15 PhD Student and 15 Engineering under contract with European Spallation Source (ESS) in Bilbao.

CZECH REPUBLIC

14) CTU Prague (Czech Technical University in Prague) - Group Leader: Jiri Limpouch
Researchers involved: Milan Kucharik, Ondrej Klimo, Lubomir Hudec

The group is involved in the theory and numerical simulations of laser interaction with targets. Methods for description of laser interaction with low density porous materials are being developed. Parametric instabilities in long corona will be also studied. We shall also take part in proposal and interpretation of interaction experiments where low density porous materials are used for creation of long hot corona relevant to the shock ignition scheme. We have participated in the recent PALS experiment on laser-foam interaction (J. Limpouch et al., Plasma Phys. Control. Fusion 62 (2020) 035013) and in the interpretation of recent experiment at SG3P installation in China (manuscript submitted for publication).

15) PALS, IPP.CR (Institute of Plasma Physics, Czech Academy of Sciences) Prague - Group Leader: Oldrich Renner,
Researchers involved: Burian Thomas, Jan Nikl, Sushil Singh

The group operates the kJ-class PALS laser system for more than 20 years. The kJ laser is precisely synchronized with femtosecond Ti:sapphire laser system. The group focuses its research on study of hot dense plasma interaction with sub-nanosecond laser and laser-solid target interaction related to inertial fusion research as shock wave generation. One of the topic is study of parametric instabilities in coronal plasma and the mitigation of their impact on hot electron generation. During the PALS laser operation, the group developed several diagnostics, as e.g. array of electron spectrometers, time-resolved X-ray plasma imaging, pinhole cameras, plasma femtosecond interferometry, Doppler velocimeter, etc.

UNITED KINGDOM

16) University of York - Group Leader: Nigel Woolsey
Researchers involved: Calum Feeman, Arun Nutter, Adam Dearling, Matthew Khan

The group is involved in all the aspects of shock ignition, and use wide range of computational and experimental facilities in the study the radiation hydrodynamics, laser-plasma interaction, and suprathermal electrons physics that can occur during indirect and direct drive irradiation of implosions. The group both leads and contributes to shock ignition related experiments across the world and access laser facilities in Europe (PALS, Phelix, LULI), the UK (Vulcan and Orion), the USA (Omega and NIF), Japan (Gekko/LFEX) and more recently China (SG IIu). A significant effort is devoted to the interpretation of Omega experimental measurements of implosion symmetry, the stimulation of parametric instabilities and hot electrons at high intensity, and the development of emerging high energy density diagnostic methods such as x-ray phase contrast imaging.

17) Central Laser Facility, STFC Rutherford Appleton Laboratory - Group Leader: Robbie Scott
Researchers involved: Ruocco Alessandro

The CLF group leads a close collaboration with the Universities of York and Warwick which collectively research both theoretical and experimental aspects of Shock Ignition and Direct Drive. Our experimental research combines the use of mid-scale facilities (Vulcan, SGIII-P) with laser-scale facilities such as Omega and NIF. Collaboratively with the Laboratory for Laser Energetics we recently proposed and performed the first shock ignition experiments on the National Ignition Facility. Our theoretical developments include the development of the Odin radiation-hydrodynamics code, the development of new 'inline' models for laser-plasma interactions, particle-in-cell modelling of laser-plasma interactions, and the development of new-laser pulse shape concepts for direct drive/shock ignition.

18) Imperial College, London - Group Leader: Jeremy Chittenden
Researchers involved: Robert Kingham, Francisco Suzuki-Vidal

The group has a long track-record in the study of dense plasma physics including inertial confinement fusion, short pulse high intensity laser plasma interactions, high energy density science and laboratory astrophysics. The group have developed a range of computational models including the 3D radiation hydrodynamics code Chimera and the extended MHD code Gorgon which have been used extensively in the design of high inertial fusion experiments. In addition the group has a broad range of models to simulate intense laser plasma interactions. The group has strong collaborations with teams at LLE, LLNL, AWE and RAL and has participated in experimental campaigns on the NIF, Omega, Orion and SG II lasers.

19) University of Warwick - Group Leader: Tony Arber
Researchers involved: Tom Goffrey, Keith Bennett, SJ Spencer, Andrew Angus, Alun Rees

The group is involved in theoretical and computational aspects of shock ignition. Warwick has developed the EPOCH kinetic code for studying laser-plasma parametric instabilities including hot-electron generation as well as the Odin radiation-hydrodynamics codes. During the previous ER-IFE project these codes have been extended to allow simple LPI models hot-electron effects to be included into Odin and EPOCH has been used to assess the hot-electron generation from the SI ignitor pulse on ignition scale facilities. The group collaborates with the RAL and York in the UK in running and interpreting UK coordinates experiments on Omega at the University of Rochester.

20) University of Strathclyde - Group Leader: Zheng-Ming Sheng
Researchers involved: Bengt Eliasson, Thomas Wilson

The group is involved in the study of development and control of parametric instabilities associated with the Shock Ignition scheme theoretically and numerically. The group has rich experience in theory and numerical modeling of laser plasma parametric instabilities with particle-in-cell codes and Vlasov-Fokker-Planck (VFP) codes, where the VFP codes have been developed by themselves. During the previous period of our ER-IFE project, they proposed the suppression of parametric instabilities in homogeneous and inhomogeneous plasma with broadband lasers and a new idea to generate such broadband lasers. In the last five years, they have published 8 papers and a book by Cambridge University Press on this topic. They have established broad collaboration with theory and experimental research groups from Europe, Asia, and USA.

21) Centre for Plasma Physics, Queen's University Belfast - Group Leader: Daniele Margarone
Researchers involved: Daniele Margarone

The Centre for Plasma Physics (CPP) at Queen's University Belfast (QUB) is one of the major plasma physics groups in the UK. The main field of investigation is the physics of plasmas created by high-intensity laser irradiation of matter or by electrical discharges, with internationally leading activities in fundamental science as well as in applied research. The research work is supported by significant funding from the UK Research Councils, as well as from other national and international sources. CPP researchers use state-of-the-art local research facilities, but are also frequent users of major national and international large-scale installations.

HUNGARY

22) Wigner RCP, Budapest - group leader: István Földes
Researchers involved: Zsolt Kovács, Imre Barna

The main profile of the group is diagnostics of laser plasmas in the visible, EUV and x-ray domains. EUV and soft x-ray experimental work with holographic and transmission gratings as well as with von Hamos spectrometer enables us to develop a new spectrometer with a collaboration of the "Femtosecond Spectroscopy and X-ray Spectroscopy Research Group" of our institute led by the former ERC Starting Grant holder, György Vankó. A strong collaboration has been carried out since decades with the Szeged University, HILL Laboratory using the short-pulse, ultraclean KrF laser system therein. Our recent experiments on the reflectivity and x-ray conversion of the UV laser is a topics of interest for direct drive inertial fusion. Our diagnostic skills enabled our group to participate in joint experiments on the PALS facility in Prague and LWS2 in MPQ, Garching.

POLAND

23) IPPLM, Warsaw - Group Leader: Tadeusz Pisarczyk
Researchers involved: Tomasz Chodukowski, Zofia Rusiniak Kalinowska, Marcin Rosiński, Agnieszka Zaraś-Szydłowska, Katarzyna Batani, Dominika Terwińska, Przemyslaw Tchorz

Experimental and theoretical investigations related to SI are mainly conducted at PALS where the Polish group also contributes to diagnostics development (e.g. femtosecond multi-frame interferometry, electron and ion emission measurements). Investigations of laser energy conversion to the SI shock have been performed, identifying the absorption process responsible for the generation of hot electrons in different irradiation conditions at both 1ω and 3ω. Femtosecond complex-interferometry allowed obtaining information about spontaneous magnetic field distributions and about the absorption process and the mechanism generation of the fast electrons.
Currently we are working on experiments connected with production of magnetized plasma by means of specially constructed targets, in particular of the capacitor-coil or snail type. In these studies, polaro-interferometry is a particularly useful diagnostics, which allows to obtain information about spatial-temporal distributions of the magnetic field combined with measurements of fast electron distribution by means of k-alpha measurements and a multi-channel spectrometer of electrons in order to obtain information about their population and energy distributions.

PORTUGAL

24) IST, Lisbon, Portugal - Group Leader: Marta Fajardo
Researchers involved: Williams Gareth, Goncalo Figueira, Joao Dias

For the past decade, the group has been developing X-ray imaging techniques and novel diagnostics for probing High Energy Density plasmas. In particular, we have been designing and implementing novel diagnostics using coherent X-ray probes, capable of retrieving the full refractive index of overdense plasmas, pioneering experiments in X-Ray lasers. We also developed expertise in coherent imaging techniques such as holography enabling unprecedented spatial and temporal resolution. We have long established expertise in X-ray lasers and coherent XUV sources. Recently, thanks to an FET-H2020 grant coordinated by IST (www.voxel-project.eu), we are developing a novel 3D x-ray camera enabling depth of field reconstruction in a single shot.

GREECE

25) Hellenic Mediterranean University (HMU) of Crete - Group Leader: Michael Tatarakis

Researchers involved: Nektarios Papadogiannis, Vasilios Dimitriou, Eugene Clark, Ioannis Fitilis, Evaggelos Kaselouris

The Institute of Plasma Physics & Lasers of HMU in Rethimno is an internationally renowned center pursuing cutting edge research on High Intensity Laser Matter Interactions. IPPL is one of two the access points of the HELLAS-CH National Research Infrastructure. The institute has state-of-the-art research facilities including a 45 TW femtosecond laser system. IPPL is pursuing research & education in High Power Laser Plasma Interactions, Ultrashort Laser Generated Secondary Sources (protons, electrons, photons), study of plasmas generated by Pulsed Power Plasma Sources (X-pinch, Z-pinch, Plasma focus), Laser Based Diagnostics Development for Plasmas and Materials, and Numerical modelling of laser generated plasmas, secondary sources, plasma instabilities. IPPL has developed dedicated education programs related to the proposed research such as the MSc course "Plasma Physics and Applications - PLAPA" developed via the Erasmus CD programme and has run various ERASMUS IP and ERASMUS+ training programs.

UCRAINA

26) National Centre "Kharkov Institute of Physics & Technology" - Group Leader: Vasyl Maslov
Researchers involved: Roman Ovsiannikov, Bilokon Valeriya, Bilokon Elvira, Bondar Denis

The group is involved in numerical simulation and analytical investigation of all the aspects of SI. The main codes for numerical simulation are 2d3v code UMKA and 2.5D code LCODE. During previous CfP-ADMIN-AWP19-ENR-01 project we numerically simulated hot electron generation, excitation of cavities on electron-time scale and on ion-time scale in inertial fusion, transverse inhomogeneity smooth in critical point at laser pulse interaction with nonuniform plasma in inertial fusion, took into account dissipation. We are Leading Research Scientist and Professor from KIPT (NSC Kharkov Institute of Physics and Technology) and students from KKNU (V.N. Karazin Kharkov National University). We collaborate with CELIA (Bordeaux), University of Rostock, University Paris-Sud. One student presented oral on the conference on the Elbe (Italy) and this year he recognized and awarded the best graduate of the year of V.N. Karazin Kharkov National University.

LIST OF EXTERNAL COLLABORATING GROUPS

The groups listed here have explicitly asked to be listed as international collaborators of our research project (confirmation emails available if needed)

JAPAN

1) ILE, University of Osaka - Group Leader: Keisuke Shigemori
Researchers involved: Norimasa Ozaki, Alessio Morace, Shinsuke Fujoka

ILE has an excellent experimental environment for shock ignition relevant study both for planar and spherical targets. For the planar experiments, the HIPER irradiation facility has a selection of irradiation wavelengths: , 2, and 3, on which we can explore hot electron effects at spike pulse regime. Also, we could irradiate spherical targets with 12 beams at another target chamber that also has an option to combine with LFEX laser, 1 ps petawatt where we can perform backlight experiment of imploded shell, for example.
We would like to contribute on control of hot electron effects for shock ignition targets. Also, we would like to explore new target design with high-density diamond ablator capsule for strong shock generation by hot electrons.

UNITED STATES

2) LLE, University of Rochester - Group Leader: Riccardo Betti
Researchers involved: A. Lees, D. Patel, V. Gopalaswamy, J. Knauer, J. Davies, J.Peebles M. Campbell

Most of the shock ignition work at LLE is related to cryogenic layered DT designs, simulations and experiments using shock ignition laser pulse shapes. Shock ignition pulse shapes use a final spike in the laser power to drive a late shock. Several designs are being tested in implosion experiments on OMEGA and they are predicted to achieve the highest fusion yield.
Several experiments will be conducted n collaboration with the “Shock ignition” Eurofusion project, both on the Omega facility and on the Omega-EP laser. The scientists involved in this effort are: R Betti (Chief Scientist), A. Lees, D. Patel, V. Gopalaswamy (Graduate Students), J. Knauer and M. Campbell (Senior Scientists).

CHINA

3) Shanghai Institute of Optics and Fine Mechanics (SIOM), Shanghai- Group Leader: Jianqiang Zhu
Researchers involved: Baoqiang Zhu, Panzheng Zhang, Lei Ren, Huiya Liu, Ping Zhu

The National Laboratory on High Power Laser and Physics (NLHPLP) at the Shanghai Institute of Optics and Fine Mechanics (SIOM) of the Chinese Academy of Sciences (CAS, is the birthplace of ICF studies in China and has built up SG-II high power laser facility with high degree of experimental flexibility for ICF research and high energy density science. SG II, and the upgrades SG II UP and SG II PW, provide nanosecond, picosecond, and femtosecond lasers at one site.
IN 2019, at the IFSA conference in Osaka, a joint “Letter of Interest” has been signed between SIOM and the research groups involved in the project Enabling Research project ENR-IFE19.CEA-01 “Study of Direct Drive and Shock Ignition for IFE: Theory, Simulations, Experiments, Diagnostics development”. A common experiment is scheduled for 2021 on the facility SG II UP. We are keen of continuing the fruitful collaboration with the new EUROFusion project on SI.
In the field of shock ignition, we will collaborate on the researches as follow:
On laser driver research: 1) Maximizing output laser energy of single beamline; 2) Accurately balancing of the laser power between beams; 3) Precisely controlling of the pulse waveforms; 4) Novel beam smoothing techniques; 5) Studying new configuration of next-generation laser drivers.
On laser plasma research: 1) Studying the parametric instabilities at the laser intense of SI both in the experiments and theory, and suppression of parametric instabilities with new laser technique; 2)

Characterization of hot electrons with angularly and spectrally resolved measurement; 3) Measuring the velocity of the shocks; 4) Detecting the shock evolution with PW laser produced radiation.

INDIA

4) Tata Institute of Fundamental Research (TIFR), Mumbai - Group Leader: G. Ravindra Kumar
Researchers involved: Amit D. Lad, M. Krishnamurthy, Ankit Dulat, Aparajit Chandrasekharan

The laser-plasma group at TIFR is working on several research themes of interest for the present project: physics of laser fusion - relativistic electron transport, giant magnetic field generation and its impact on the transport, transport in nanochannels and such specially designed geometries, electron and ion acceleration, bright particle sources and dynamics and control of laser induced shocks.
In addition, the group has a long collaboration history with several groups of the EUROFusion network (CELIA, York, etc.)

RUSSIA

5) Joint Institute of High Temperatures, Russian Academy of Sciences, Moscow – Group Leader: Sergey Pikuz – head of DiagMEC laboratory (spikuz@gmail.com)
Researchers involved: Konstantin Khishchenko – head of EoS laboratory, Pavel Levashov - head of Theory, Igor Skobelev, Sergey Ryazantsev, Eugeny Filippov and 6 PhD students

JIHT RAS (directed by Prof. Vladmir Fortov) is the leading Russian institution and academic expert center for Energetics, High Energy Density Physics, Plasma and Material Sciences.
The institute is actively participating in several international collaborations on HEDP being a frequent user of large-scale European laser and accelerator facilities.
Areas of expertise include:

- Development, production and characterization of X-ray diagnostic equipment (X-ray imaging spectrometers, imaging detection systems) and diagnostic methods (high-resolution X-ray imaging, X-ray spectroscopy treating as expanding recombining as over-dense and/or radiatively pumped or large-gradient plasmas)
- Radiation atomic kinetics simulation and the analysis of multicharged ion X-ray spectra
- Numerical simulations and theoretical support for wide-range equation of states

JIHT RAS is intended to be involved in research on the following topics in the frame of the project:

- Extreme states in dynamically compressed matter and broad-range equation of states;
- Characterization of hot electrons and hot-electron-driven shock ignition;
- Study of hydrodynamic and parametric instabilities in direct drive implosions;
- Radiation emissivity and transport properties of solid and foam targets;
- Magnetized plasma flows and magnetic-assisted implosions

6) Institute of Laser and Plasma Technologies, MEPhI National Nuclear Research University, Moscow – Group Leader: Philipp Korneev
Researchers involved:Andrey Kuznetsov, Sergey Popruzhenko, Philipp Korneev, Iurii Kochetkov, Nikolai Bukharskii

MEPhI group of plasma physics is a part of the Institute of Laser and Plasma Technologies (LaPlas) in MEPhI National Nuclear Research University. The group, which is working both in theory and experiment, has an expertise in a wide range of problems related to laser-matter interaction and plasma physics, including magnetic field generation, perspective directions in Inertial Confinement Fusion, particle acceleration, quantum processes in strong fields, laboratory astrophysics. Both experienced and young scientists are participating in experiments carried out at open access research laser facilities over the world. The group has a long-term and productive collaboration within Europe, including European Light Infrastructure and PALS in Prague, CELIA laboratory in Bordeaux University, Darmstadt Technical University and others.

FRANCE

7) CEA, DAM, DIF, F-91297 Arpajon Cedex, France – Group Leader: Pascal Loiseau
Researcher involved: Arnaud Debayle

Pascal Loiseau and Arnaud Debayle are theoretical and computational plasma physicists working in the inertial confinement fusion field, with a strong expertise in laser-plasma interaction. Their research are motivated by the mitigation of the so-called parametric instabilities such as Brillouin or Raman scattering that occur when a high power laser propagates through a long, hot and inhomogeneous plasma. This situation applies both in direct and indirect drive and need a careful description of the laser-plasma coupling. This last point has motivated recent research regarding electron transport in hot plasmas, and more specifically by considering non local effects in heat transport and the effect of plasma magnetization.
They also regularly participate to the design and interpretation of laser/plasma experiments.
Numerical modeling:

- 2D/3D kinetic modeling using mass-parallel particle-in-cell simulations
- 2D/3D hybrid hydrodynamic-kinetic code to describe the hydrodynamic evolution coupled with relativistic charged particle transport and x ray emissions
- 2D/3D radiation magneto-hydrodynamic simulations