

## Summary

### of the Franco-Russian ISTC Workshop on the physics with PETAL and the diagnostic development, March 9 - 11, 2009, Le Barp, France

2<sup>nd</sup> Franco-Russian ISTC Workshop has been organized by the Institute of Lasers and Plasmas (ILP) and International Science and Technology Center (ISTC) with the objective to facilitate the scientific exchange between the Russian scientists from leading research institutes working in the domain of high intensity laser physics and French scientists working on the large scale project PETAL, to define the diagnostic and large optics equipment for the PETAL installation that could be constructed and employed on a collaborative basis.

**ISTC** is an intergovernmental organization connecting scientists from Russia, Georgia and other countries of the Commonwealth of Independent States with their peers and research organizations in Canada, European Union, Japan, Republic of Korea, Norway and the United States.

**PETAL** is a 3.5 kJ, 0.5 – 10 ps, PetaWatt-class laser which is under construction in the Aquitaine region, France. It is a fore-runner to the HiPER facility dedicated to studies of the inertial confinement fusion physics by using the fast ignition approach and fundamental physics. Its mission is to address the physics and technology issues of strategic relevance for the fast ignition and provide a framework for the basic studies of the matter properties at extreme conditions.

The Workshop provided a forum for successful exchange of knowledge, information and future plans of scientific and technical collaboration. The program of the Workshop is presented in Appendix 1 and the list of participants – in Appendix 2. The propositions for further collaborative projects are presented in Appendix 3.

The Russian scientists expressed their interest in development of some the diagnostic equipments for PETAL installation. In exchange, the Russian scientists could have a possibility to participate in the PETAL experiments and to have access to the experimental data. To facilitate the collaboration and to prepare further experiments, the diagnostic equipment and procedures, the Russian party invited the French scientists to take part in experiments on the FEMTO facility in the Russian Federal Nuclear Center in Sarov. Precise forms and conditions of these collaborative activities will be an object of further discussions between the representatives of both parties.

The participants acknowledged an efficient and fruitful exchange between the French and Russian scientists at the first Workshop (Moscow, November 2008) and the second Workshop (Le Barp, March 2009) and agreed to continue the organization of such meetings on the periodic basis once a year. The subjects of future workshops will be defined on the consultative basis. They can be more focused on the specific scientific and technical issues. Participation of scientists from other countries, in particular from Germany, United Kingdom, and Czech Republic, will be welcomed.

The participants of the Workshop are encouraged to prepare and to submit their bilateral projects concerning the fundamental physics of high intensity laser-matter interaction and the diagnostic development for the PETAL project within the ISTC framework and/or the agreement between the CNRS and the RFBR.

The Workshop has been concluded with the signature of the **Memorandum of Understanding** between the **Association Lasers and Plasmas** and the **Federation of Research Lasers and Plasmas** from the French side, the **Russian Academy of Sciences** from the Russian side, and the **International Science and Technology Center**.

## Appendix 1: Workshop program

### Monday, March 9 Plenary session: Physics of laser-plasma interactions at relativistic intensities and the PETAL facility

9h00 – 9h15	P.Mora, Opening, welcome address
9h15 – 9h35	J.Néauport, Presentation of the PETAL installation, status and perspectives
9h40 – 10h05	N.Andreev, Extreme states of matter under the action of intense laser pulses
10h10- 10h35	M.Koenig and group PHARE, Program for the fast ignition studies on the PETAL facility
11h00-11h25	V.N.Derkach, Equation of state experiments on the Luch facility
11h30-11h50	M.Koenig and group MHEDOC, Program of experimental studies of the matter properties at high densities and pressures
11h55-12h20	S.A.Belkov, FEMTO laser facility and studies of charged particle acceleration with ultra-short laser pulses
14h00-14h25	J.P.Chièze and group ASTRO, Laboratory astrophysics with PETAL
14h30-14h55	I.V.Glazyrin, Computational challenge of the hybrid PIC-fluid-MCC code for laser-plasma interaction and particle propagation
15h00-15h25	V.Tikhonchuk, Laser acceleration of charged particles, perspectives for PETAL
15h30-15h55	E. A. Loboda, Ultra-shot laser pulse experiments in RFNC-VNIITF
16h20-16h40	A.Casner, Presentation of the diagnostic equipment in the LIL interaction chamber
16h45-17h10	I.Skobelev, Possible diagnostics for experiments on PETAL
17h15-17h35	S.Hulin, Planning of diagnostic design for PETAL
17h45-18h00	D.Raffestin, Vulnerability of diagnostics
18h00-18h30	Concluding discussions, moderators: V.Yu.Bychenkov, A.Casner

### Tuesday, March 10 Visit of laser installations and round table discussions

8h45 - 12h30	Visit to the CESTA installations PETAL and LMJ
14h00-18h00	Two parallel round table discussions: short 10' presentations and discussions with the objective to establish common projects and research programs.

*Round table 1:* Physics with the PETAL: challenges and limitations  
Moderators: N.E.Andreev, I.V.Glazyrin, P.Mora, G.Schurtz

*Round table 2:* Diagnostic development for PETAL  
Moderators: S.G.Garanin, A.Shikanov, A.Casner, S.Hulin

### Wednesday, March 11 Roadmap for future collaborations, signature of documents

8h45-9h10	N.E.Andreev, Summary of the round table 1
9h20 – 9h45	S.Hulin, Summary of the round table 2
10h00-10h20	P.Mora, International collaboration around PETAL
10h50-11h30	General discussion, closing remarks
11h30-11h45	Signature of the conference documents

## **Appendix 2: List of Participants**

### **FRANCE**

#### **Conseil Régional d'Aquitaine**

Ambre Nelet, Jean-Marc Orgogozo

#### **Institut Lasers et Plasmas**

Francis Hardouin, Henry Hutchinson, Christine Labaune, Patrick Mora

#### **CEA/DAM**

Daniel Malys, Thierry Massard, Jacques Ebrardt, Jean-Luc Miquel

#### **CEA/CESTA**

Alexis Casner, Bruno Le Garrec, Philippe Estrailier, Jérôme Néauport, Didier Raffestin

#### **CEA/DSM**

Jean-Pierre Chièze, Silvine Turck-Chièze

#### **CELIA, University Bordeaux 1**

Philippe Balcou, Stanley Davis, Jean-Luc Feugeas, Ludovic Hallo, Sébasiten Hulin

Philippe Nicolaï, Jan Pšikal, Xavier Ribeyre, Guy Schurtz, Vladimir Tikhonchuk

#### **CENBG, University Bordeaux 1**

Jean-Nicolas Scheurer

#### **LULI, Ecole Polytechnique**

Michel Koenig

### **GERMANY**

#### **GSI, Darmstadt**

Theodor Schlegel

### **INTERNATIONAL SCIENCE and TECHNOLOGY CENTER (ISTC)**

Gudowski Waclaw, Malakhov Yury

### **RUSSIA**

#### **Lebedev Physics Institute RAS (LPI)**

Brantov Andrey, Bychenkov Valery, Guskov Sergey, Rupasov Alexandr, Shikanov Andrei

#### **Joint Institute for High Temperatures RAS (JIHT)**

Andreev Nikolai, Skobelev Igor

#### **Vavilov State Optical Institute GOI**

Andreev Alexander

#### **Moscow State University (MSU)**

Saveliev-Trofimov Andrey

#### **Russian Federal Nuclear Center-VNIITF**

Glazyrin Igor, Loboda Evgenii, Potapov Anatolii

#### **Russian Federal Nuclear Center-VNIIEF**

Belkov Sergey, Garanin Sergey, Derkach Vladimir, Rogachev Vladimir, Shagalkin Yuri

## Appendix 3: Program of scientific cooperation for PETAL

### Round Table 1: Physics with the PETAL: Challenges and limitations

The discussion on this round table concerned with the key physical problems that can be approached with the PETAL installation or in joint PETAL+LIL experiments.

**G. Schurtz** (CELIA) presented the program of research on the inertial fusion in CELIA and a potential of PETAL for addressing the bottlenecks: stability of target compression and the laser-plasma interaction physics, the generation of high amplitude shocks and the role of hot electrons, the fast ignition issues related to the cone survival, fast electron generation and transport. The need of reproducible and robust particle sources has been underlined.

**J.-N. Scheurer** (CENBG) presented a program of nuclear physics research with high intensity lasers. The usefulness of the nuclear activation diagnostics has been emphasized. The of the CENBG proposed to study the NEET process with the isomeric nuclei  $\text{Rb}^{84}$  on PETAL+LIL experiment.

Several presentations were related to the physics of proton acceleration with lasers. **A. Andreev** (GOI) discussed the utilization of mass limited targets for more efficient proton acceleration. A possibility to use a nanostructured front target surface in order to improve the laser-plasma coupling has been demonstrated. Collaboration in the 3D simulations of laser interaction with mass-limited targets is proposed as well as the fabrication of such targets and joint experiments on the laser in RICTOED, Sosnovy Bor. **A. Brantov** (LPI) proposed a scheme of optimization of proton production in laser plasma interaction and demonstrated 3D PIC simulations that predict generation of 200 MeV protons with a 30 J laser pulse from a mass-limited target. **S. Guskov** (LPI) discussed a possibility of light ions (He, Li, Be, B, C) acceleration with PETAL laser and their application for the fast ignition of fusion targets. The effect of the Bragg peak opens possibilities for fine tuning of the energy deposition. Further studies can be conducted as a collaboration project.

The following subjects have been identified as suitable for collaboration and for designing experiments for PW-scale lasers:

**I. Physics of fast ignition:** cone survival, transport of high currents of charged particles in hot dense matter, choice of the carrier particles and optimization of ignition conditions, issues related to the shock ignition.

**II. Astrophysics in laboratory with lasers:** radiation accretion shocks in young stellar objects, opacity measurements for the stellar interiors, equations of state for the planet interiors. *In view of limited number of shots available at the first stage of the PETAL program, it was considered to conceive and to propose the experiments that can benefit both the astrophysical and the ICF communities.*

**III Fundamental physics:** nuclear physics with lasers (production of isomeric nuclei), physics of high intensity laser plasma interaction (strong magnetic and electric fields, nonlocal energy transport), high energy density physics (development of new, more detailed equations of state, studies of transport and optical properties of non ideal plasma, modeling of atomic transitions and opacities), laser driven melting and ablation (especially with sub-ps laser pulses). *In particular, the studies in the domain of equations of state, transport and optical properties of non ideal plasma can strongly benefit from the collaboration between the scientists of JIHT and the consortium MHEDOC.*

It was mutually acknowledged that the collaboration in the domain of development of **secondary sources** of energetic charged particles, neutrons and radiation is absolutely necessary for all envisioned applications of PETAL and the collaboration in this domain is strongly advised. The particular subjects of collaboration could be: production of quasi-monoenergetic and stable source of protons with the energy  $\sim 200$  MeV for medical applications, laser wake field electron acceleration, new sources of X-ray radiation using solid and nano-structured targets, powerful sources of THz radiation, laser-driven gamma-ray sources.

## **Round Table 2: PETAL diagnostics**

Several propositions for joint development of the diagnostic equipment for the PETAL experiments have been identified.

### **Preplasma diagnostics**

The proposition of Russian colleagues consists in using a probe beam for diagnostics of the effect of the PETAL prepulse on the target. It is suggested to measure the shape of the preplasma on grazing incidence by using the shadowgraphy, interferometry and polarimetry. The possibility of having a probe beam needs to be studied. It might be possible to use the laser from VISAR station.

Moreover, a specific diagnostic can be developed that will allow to measure the pulse contrast in each shot with a very high dynamic range. This point is crucial and it needs more deep discussions.

*Contact persons:* Rupasov Alexander, LPI, Sébastien Hulin, CELIA

### **Proton streak camera, version 1**

Russian scientists from RFNC-VNIITF propose to develop a proton streak camera. A scintillator will be used for converting the protons in photons. A streak camera looking the backside of spectrometer provides a temporal resolution of the signal. The proton spectrum is obtained by measuring their time of flight.

*Contact persons:* Loboda Evgenii, RFNC-VNIITF, Sébastien Hulin, CELIA

### **Proton streak camera version 2**

Russian scientist from RFNC-VNIIEF propose to develop a proton streak camera that used special type cathode and secondary electron emission to convert protons current to electron current. The electron current is amplified in the EOC and a proton image with a high space and time resolution is registered using a CCD.

*Contact persons:* Belkov Sergey, RFNC-VNIIEF

### **High resolution X-ray spectroscopy**

In the region 10-20 keV a Mica crystal can perform measurements. The crystal curvature can be chosen from 100 mm up to few meters. So we can consider the practical possibility to use such type of crystal in the LIL diagnostic station DP 1.12

*Contact persons:* Skobelev Igor, JIHT-RAS, Sébastien Hulin, CELIA

### **K-alpha imagery**

A similar arrangement can be applied for the K-alpha imagery. With mica crystals in the 10-20 keV it seems possible to study the substrate geometry (spherical) for K-alpha imagery over 10keV.

*Contact persons:* Skobelev Igor, JIHT-RAS, Sébastien Hulin, CELIA

### **Transmission spectrometry**

with very thin multilayers it is possible to obtain a transmission spectrum over 10 keV

*Contact persons::* Saveliev Andrey, MSU, Sébastien Hulin, CELIA

### **Thomson spectrograph**

The GOI/RICOTOD volunteers for construction of the Thomson spectrograph for the fast proton diagnostics on PETAL. The unit that is actually under development has the magnetic field 0.2-0.3 T, a size of 60×60×250 mm and a weight of 6-8 kg. It allows recording the protons in the range of 2 – 150 MeV.

*Contact persons:* Andreev Alexander, GOI, Sébastien Hulin, CELIA