This project has received funding from the European Union's Horizon 2020 Research and Innovation programme under Grant Agreement No 730871.

Possible scenarios for dynamic tests (in coming months)

2nd Annual Meeting of Aries WP17

Lorenzo Peroni (POLITO)

Task 3 description

Task 3: Dynamic testing and online monitoring

Testing of material samples in a broad range of environments:

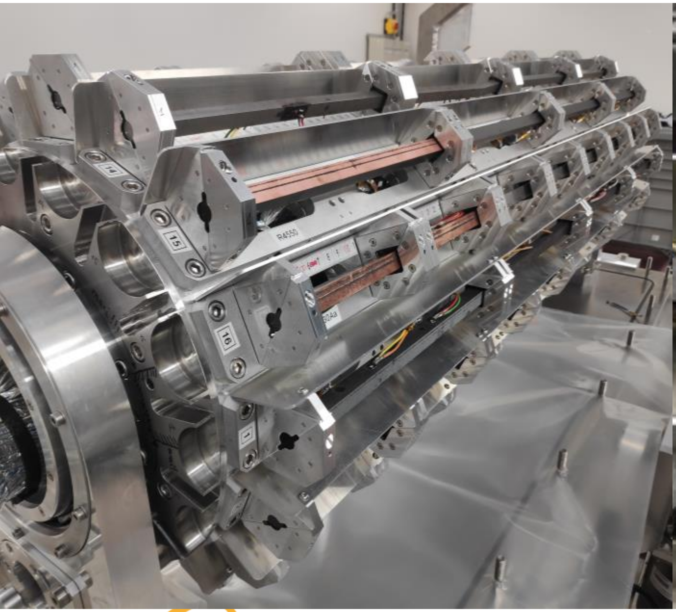
- Mechanical testing in quasi-static and dynamic conditions, at various temperatures (postponed due to COVID emergency and Vacuum chamber delay)
- **Tests under very high power laser and particle beams**
- Irradiation tests with online monitoring of properties evolution
- Hydrodynamic simulations of experiments - constitutive models, spall strengths for new materials

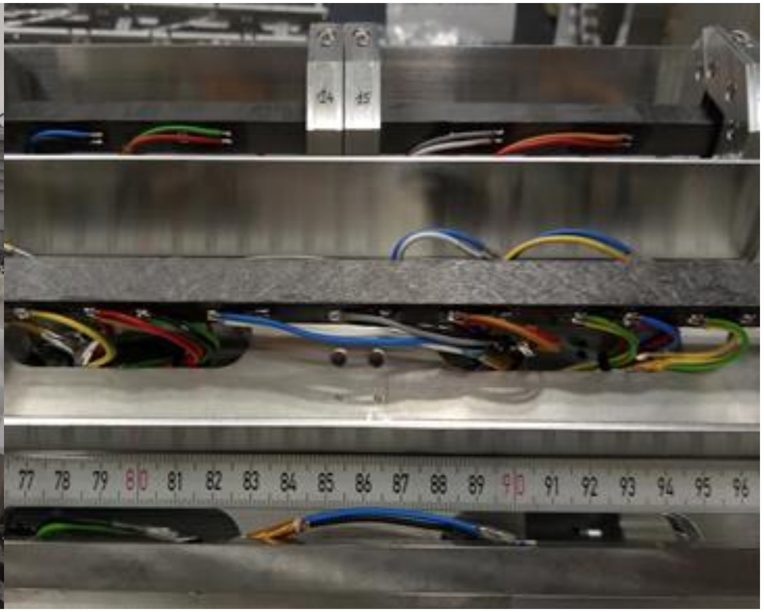
Participants: CERN, ELI-NP, GSI, POLIMI, POLITO

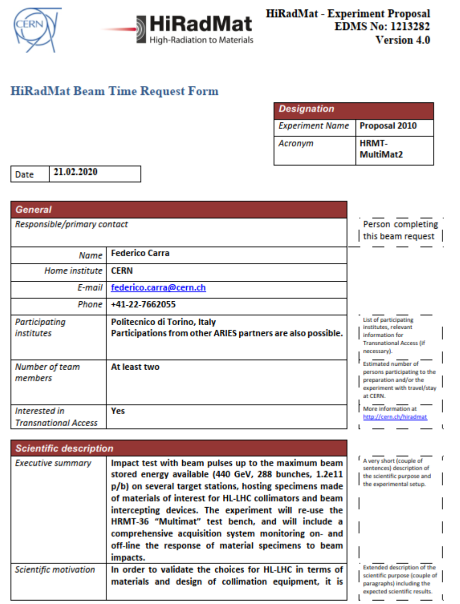
ARIES

High energy particle beams: Multimat-2

- Experiment on materials samples proposed for **next HiRadMat run (2021/22)**
- **Goals**: validate the industrial solutions for HiLumi (MoGr NB-8404Ng with HIPIMS coating, coated graphite); improve definition of material models for graphitic materials; explore collimator threshold of damage.
- Makes use of the **MultiMat test bench**, with new targets
- Open to additional materials of interest from other projects, **including ARIES!**
- **Submitted to the HiRadMat scientific board in June and under evaluation**







HiRadMat High-Radiation to Materials

HiRadMat - Experiment Proposal
EDMS No: 1213282
Version 4.0

HiRadMat Beam Time Request Form

Designation	
Experiment Name	**Proposal 2010**
Acronym	**HRMT-MultiMat2**

Date	21.02.2020

General	
Responsible/primary contact	
Name	**Federico Carra**
Home institute	**CERN**
E-mail	**federico.carra@cern.ch**
Phone	**+41-22-7662055**
Participating institutes	**Politecnico di Torino, Italy Participations from other ARIES partners are also possible.**
Number of team members	**At least two**
Interested in Transnational Access	**Yes**

Person completing this beam request

List of participating institutes, relevant information for Transnational Access (if necessary).

Estimated number of persons participating to the preparation and/or the experiment with travel/stay at CERN.

More information at http://cern.ch/hiradmat

Scientific description	
Executive summary	**Impact test with beam pulses up to the maximum beam stored energy available (440 GeV, 288 bunches, 1.2e11 p/b) on several target stations, hosting specimens made of materials of interest for HL-LHC collimators and beam intercepting devices. The experiment will re-use the HRMT-36 "Multimat" test bench, and will include a comprehensive acquisition system monitoring on- and off-line the response of material specimens to beam impacts.**
Scientific motivation	**In order to validate the choices for HL-LHC in terms of materials and design of collimation equipment, it is**

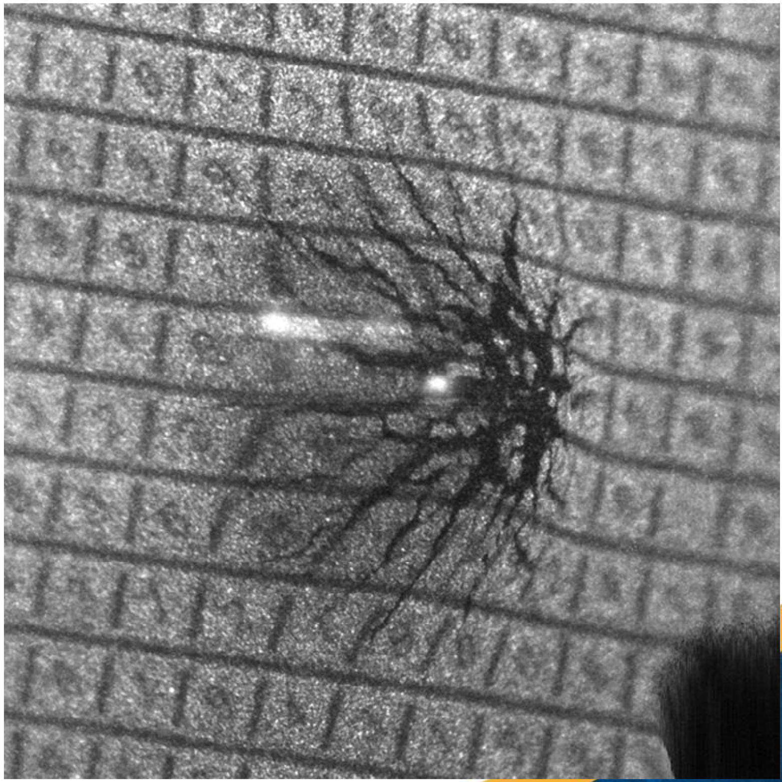
A very short (couple of sentences) description of the scientific purpose and the experimental setup.

Extended description of the scientific purpose (couple of paragraphs) including the expected scientific results.

Laser Shockwaves (I)

From the beginning of their development, high-power laser facilities have always been considered as **potential calibrated-shock generators**. Indeed, the interaction between the laser and the front face of a solid target generates a plasma whose expansion creates a shock wave into the matter that may lead to its failure.

The shock pulses are created due to the rapid heating of the surface from the photon bombardment of the material. The surface heats and expands, forming a plasma. Because of the rapid heating and thermal expansion, the front of the material is shock compressed at times on the order of nanoseconds. This pulse then propagates through the material as a shock wave. The heat effects from the laser irradiation are limited to the first few atomic planes.



Laser Shockwaves (II)

In many cases, laser induced shock waves experiments are produced when focusing a short-duration and high energy pulsed laser beam (~ ns, ~ J) on a small solid surface. In such a situation, the density of power increases up to the value of some GW/cm²:

$$\phi = \frac{E_{max}}{\tau \cdot S}$$

E_{max} is the maximum energy delivered by the laser source during duration τ and S is the surface irradiated by the laser beam.

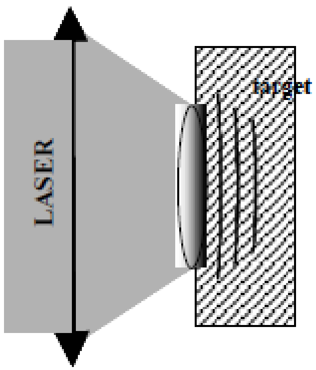
Under these conditions, the solid matter is quasi instantaneously dissociated into plasma and starts its sudden expansion, in the same way as detonation products of high explosive do.

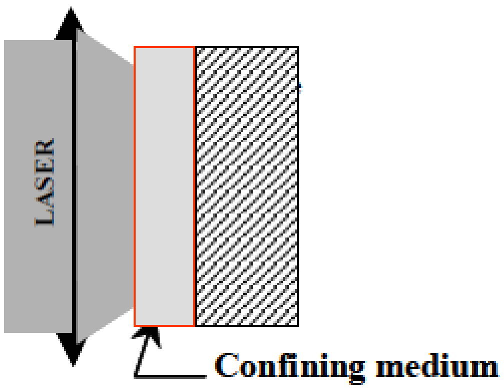
Laser induced shockwave as delaminator for composite material for ballistic protection at high strain rate

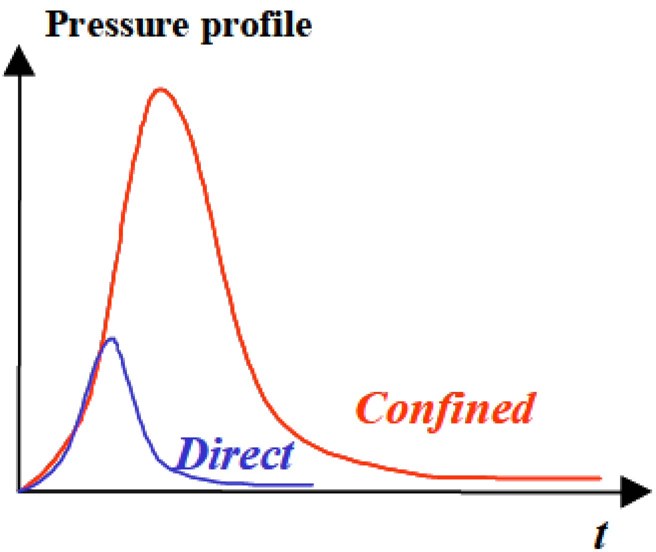
Luminita-Christina ALIL[1], Michel ARRIGONI[2-[orcid.org/0000-0002-7237-3303]], M. ISTRATE[3], Alexandr KRAVCOV[4], Jérémy LE PAVIC[2], Gilles TAHAN[2]

Laser Shockwaves (III)

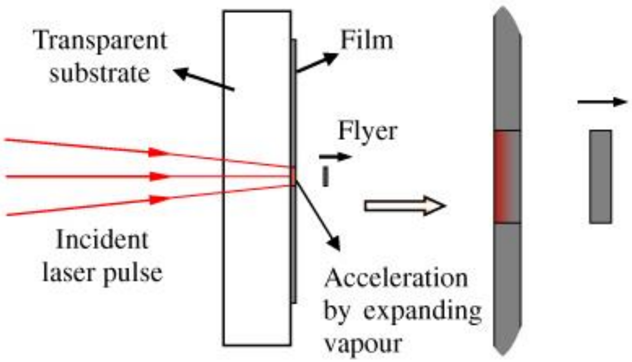
Two modes of interaction are distinguishable according to whether the plasma expands freely (direct interaction) or is retained by a transparent medium confining the plasma







The generated shock could be used to test a specimen or to drive a flyer plate for an impact test

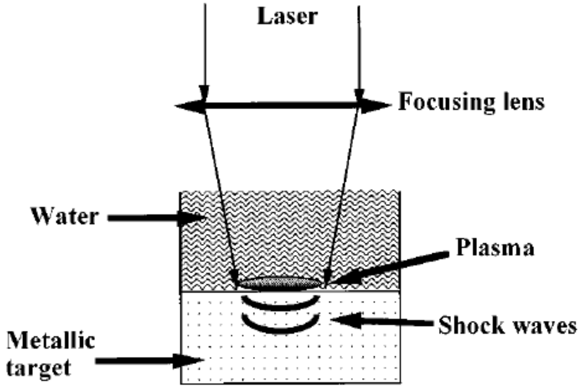


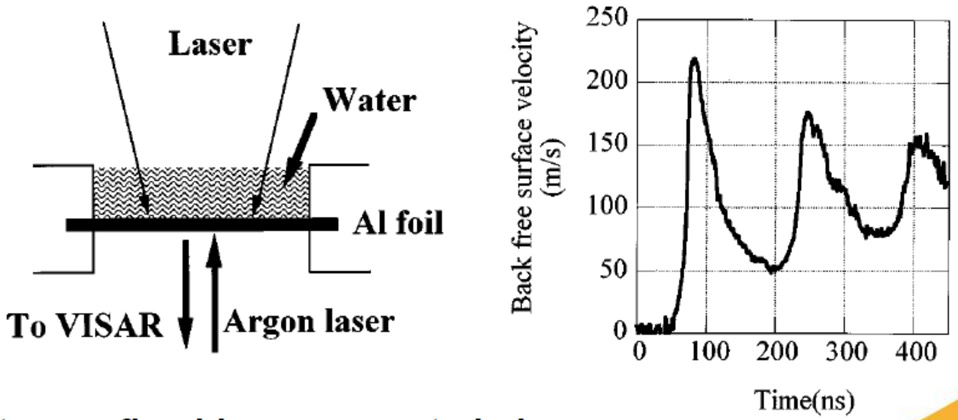
Some examples

"High power pulsed laser (**above 1GW/cm²**) interaction with matter yields to very high amplitude pressure loadings with very short durations, initiating into solids a strong short shock wave. Compared to the conventional generators of shock (launchers of projectiles, explosives), these particular characteristics offer the possibility to study the behavior of matter under extreme dynamic conditions, with a possible recovery of the shocked samples presenting the effects of the passage of the shock in most cases"

Laser Shock Waves: Fundamentals and Applications

Michel BOUSTIE [1], Laurent BERTHE [2], T. de RESSEGUIER [1], Michel ARRIGONI [3]





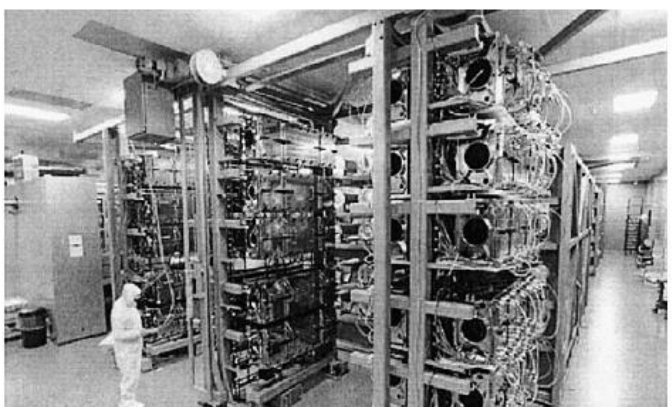
Shock waves from a water-confined laser-generated plasma

L. Berthe, R. Fabbro, P. Peyre, L. Tollier, and E. Bartnicki

Some examples

The shock experiments were carried out at the OMEGA Laser Facility at University of Rochester’s Laboratory for Laser Energetics (LLE). The input laser energies used in the experiments were 70, 200, and 300 J with a 2.5 ns pulse duration. The laser spot size was 3 mm. This experimental setup provided energy densities on the order of 50 MJ/m^2.

VISAR wave profile measurements were also performed during these experiments to obtain time-resolved data on the shock wave profile as it breaks from the free surface. Samples of various thicknesses were irradiated with different laser intensities to obtain the different release profiles.



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INTERNATIONAL JOURNAL OF IMPACT ENGINEERING

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Laser shock compression of copper and copper–aluminum alloys

Matthew S. Schneider[a], Bimal Kad[a], Daniel H. Kalantar[b], Bruce A. Remington[b], Edward Kenik[c], H. Jarmakani[a], Marc A. Meyers[a,*]

[a]Materials Science and Engineering, University of California, San Diego, MC 0418, La Jolla, CA 92093, USA
[b]Lawrence Livermore National Laboratory, Livermore, CA 94450, USA
[c]Oak Ridge National Laboratory, Oak Ridge, TN 37831, USA

Some examples

Luli2000 is a high-power laser facility of the Laboratoire pour l'Utilisation des Lasers Intenses (LULI) based at the École Polytechnique (Palaiseau, France). This laser generates square temporal pulses tunable from 0.5 to 5 ns and can reach energies up to 1 kJ at the wavelength of 1064 ns.


Contents lists available at ScienceDirect

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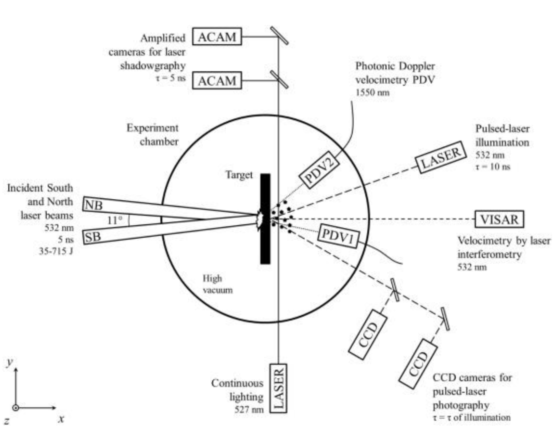
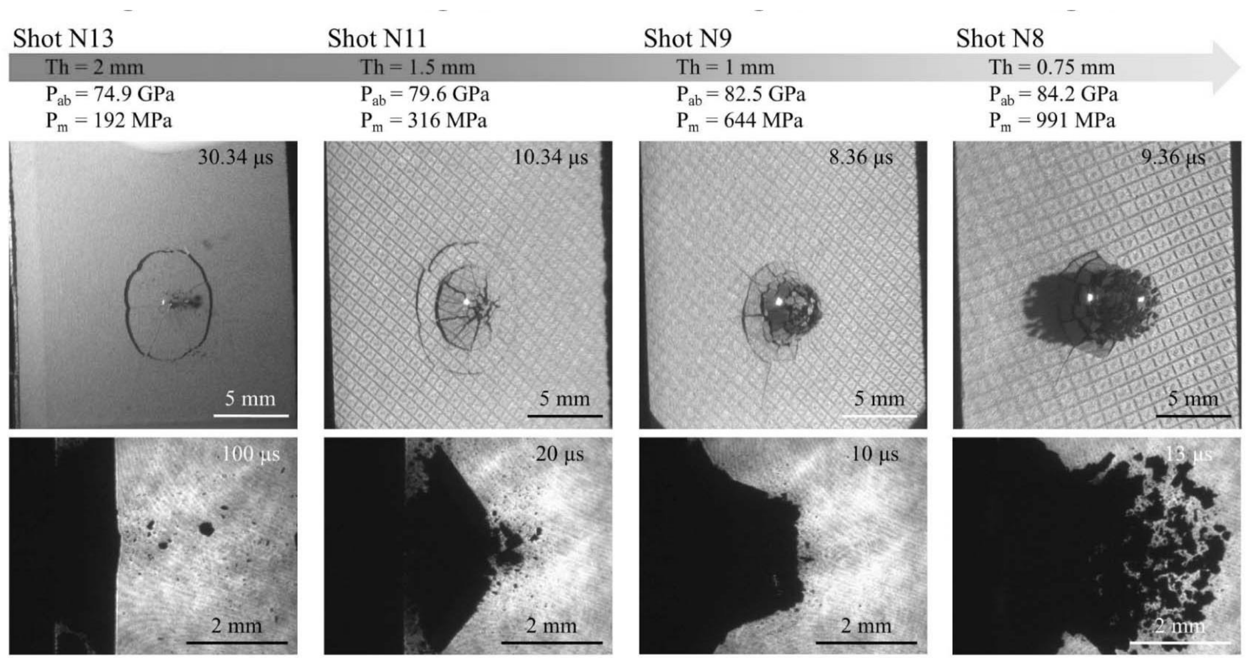
Dynamic fragmentation of graphite under laser-driven shocks: Identification of four damage regimes

G. Seisson [a,*], G. Prudhomme [a], P.-A. Frugier [a], D. Hébert [b], E. Lescoute [a], A. Sollier [a], L. Videau [a], P. Mercier [a], M. Boustie [c], L. Berthe [d]

[a] CEA DIF, Bruyères-le-Châtel, 91297 Arpajon Cedex, France
[b] CEA CESTA, 15 avenue des Sablières CS60001, 33116 Le Barp Cedex, France
[c] Institut P' – UPR3346 CNRS-ENSMA-Université de Poitiers, 1 avenue Clément Ader, 86961 Futuroscope Cedex, France
[d] Laboratoire PIMM – UPR8006 CNRS-Arts et Métiers ParisTech, 151 boulevard de l'Hôpital, 75013 Paris, France





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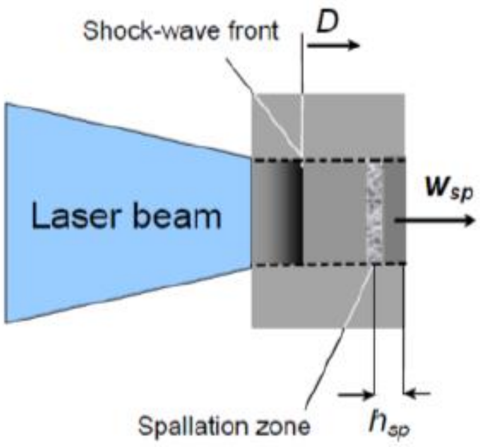
WP17 partners capabilities

Within the experiment P089, investigations of spallation phenomena in different graphite grades, copper-diamond and molybdenum-graphite composites were conducted at the Z6 experimental area, using shock waves induced by the PHELIX laser at GSI. A pulsed laser beam with a wavelength of 530 nm, 1.4 ns pulse duration and energies of 120 J was focused to a spot size of 1.3 mm on the target. Typical beam intensities were about 0.6×10^{13} W/cm^2.



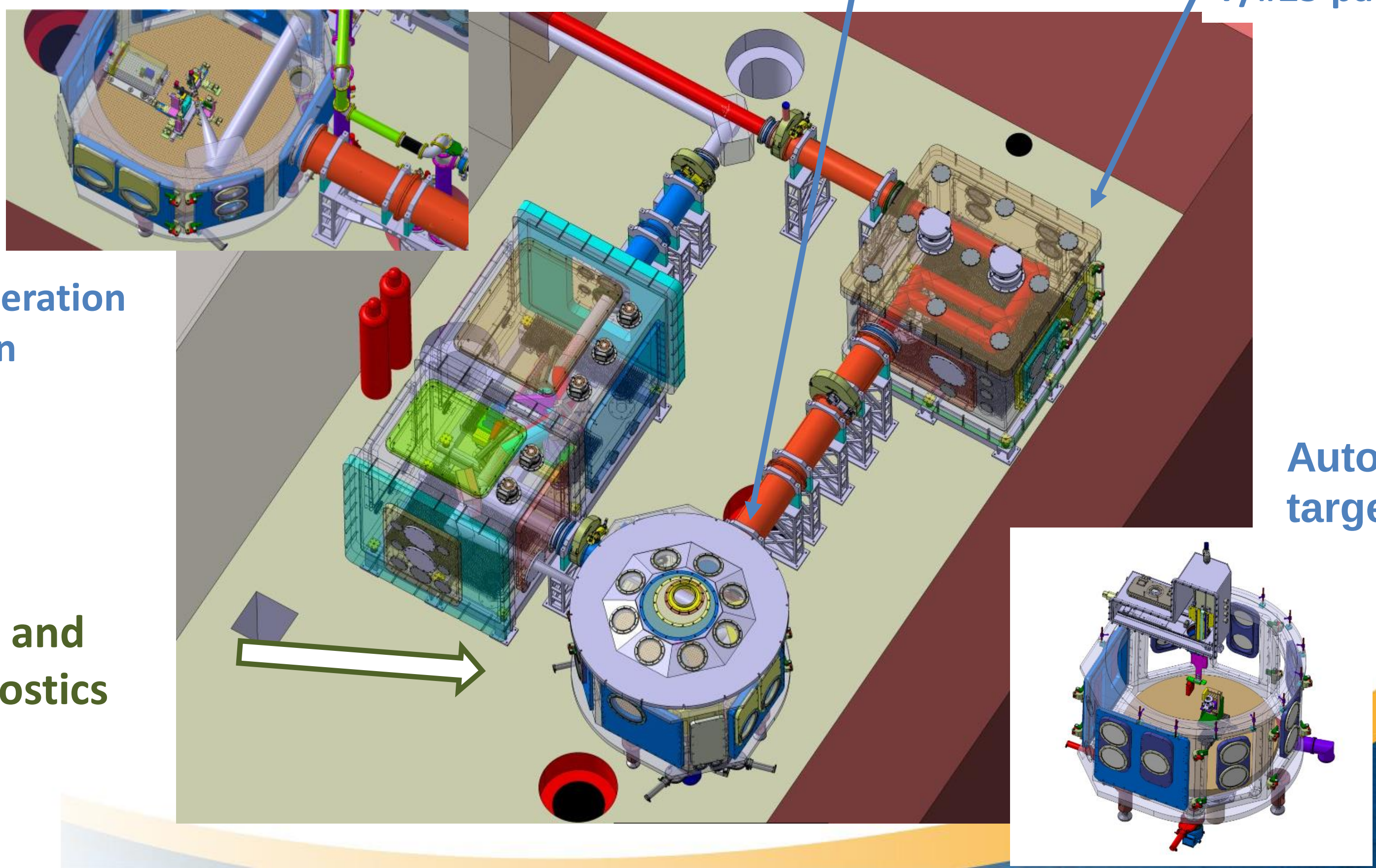
Investigation of high power laser -induced spallation phenomena in target and collimator materials for next generation accelerators*

M. Tomut[1,2,#], I. Krasiuk[3], T. Rienecker[4], O. Rosmej[1],I. Stuchebryukovr[5], A. Schönlein[1], K. Khischenko[3], R. Belikov[6]

[1]GSI, Darmstadt, Germany; [2]NIMP, Bucharest, Romania;3Joint Institute for High Temperatures, RAS; [4]Goethe-Universität Frankfurt, Germany;[5]Prokhorov General physics Institute, RAS; [6]Moscow Institute for Physics and Technology, Moscow, Russia

What’s next in PowerMat

- Status of E5 Experimental Area for Materials Research at **ELI-NP**, Bucharest (2 x 1 PW Lasers)
  - 2018 - 2019 – finalization of 1 PW optics and interaction chambers in E5
  - mid 2019 – laser beam characterization; proton acceleration; **first experiments**



In the near future

- Is it possible to plan laser driven shockwaves experiments in the next months?
- Which Laser Source will be available for these tests (GSI, ELI-NP…)? Which energy level, pulse duration, spot size…?
- Which instrumentations will be available through the Powermat partners (VISAR, Fast cameras…)
- Which materials could be good candidates?
- Is it the timeline compatible with the ARIES end?

This project has received funding from the European Union's Horizon 2020 Research and Innovation programme under Grant Agreement No 730871.

Thank you!