ARIES

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MINUTES AND ACTIONS

PHELIX Progress Meeting

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	Name
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1 P219 Experiment at GSI-PHELIX: Introduction, Status, Planning (A. Bertarelli)

AB introduced the experiment and reminded the goal of this progress meeting which was mainly to define the list of materials to be tested and diagnostic tools to be used.

Due to PHELIX crowded schedule, the experiment had to be postponed to January 2022, with two alternative slots (starting on 10th or 31st January). AB stressed that these dates are beyond the formal closure date of the WP17, and therefore no spending can be charged on WP17 budget codes in 2022; however AB also mentioned that an informal agreement was found with ARIES coordinator, by which travel and subsistence costs incurred in 2022 can exceptionally be charged on WP1 budget, on which will be transferred the remaining funds from WP17 on 31st December 2021.

During the meeting it was agreed that the second window, starting on 31st is chosen. Transnational Access (TNA) funding is available for indicatively two persons through Laserlab Europe. The application must be submitted by end of June (**Action 1**). Given that not all partners are eligible it was agreed that researchers from POLITO and UniRoma would be proposed, with possible addition of participants from CERN. The names should be included in the TNA application (**Action 2**).

The total number of specimens proposed for testing should be ~40, plus ~10 for set-up. VB commented that testing 40+10 samples seems very challenging, even if some extra days may be asked. AB replied that a list of specimens and materials should be prepared, with a priority order to favour more relevant materials; it shall be annexed to the minutes of the meeting (**Action 3**). MT should provide samples of Bulk amorphous alloy and High-entropy alloys (**Action 4**)

AB reminded that we the experiment is assigned 10 days including 5 days of preparation.

VB commented that the day to set-up the experiment and do some benchmarking are counted as operation days. The facility can be accessed before installing components in the area. On the first official day the optical alignment can start.

VB strongly recommended a visit in October/November to be ready for the technical design report (TDR) that should be ready two months before the experiment (**Action 5**). AB replied that this should be certainly organized, compatibly with the sanitary situation and possible travel restrictions (**Action 6**).

In a previous message, VB also mentioned that the support from a student from MEPhI, Moscow, who was very well acquainted with GSI VISAR and could have helped with the target design and analysis of the VISAR images is unfortunately no longer available.

A series of questions were raised; they are reported in section 4.

2 Simulations results (L. Peroni)

LP presented an overview of the simulations performed at ELI-NL and POLITO on graphite targets to study the experimental conditions expected in P219. An original methodology combining two codes, HELIOS and LS-DYNA, was introduced: the main idea is to use HELIOS for the thin portion (~ 30 µm) of the sample which is reached by the shock-wave during the laser deposition time (5 ns) and rely on LS-Dyna to study the evolution of the phenomenon in the remainder of the specimen. The approach has been benchmarked with the experimental results presented in [1]. In order to correctly compute the response of the various specimens it is important to evaluate the equations of state (EOS) of the materials tested and to better know the distribution of the laser intensity. EOS for the more complex materials should be proposed (**Action 7**) in order to continue the simulations at POLITO, while the actual spatial distribution of the laser pulse intensity should be provided (**Action 8**).

3 Logistic and instrumentation at GSI-PHELIX (C. Brabetz)

CB presented the set-up of the VISAR available at the Z6 experimental station. He explained that the VISAR instrumentation table is placed 3-4 m above the target vacuum chamber. A telescope available if the samples need to be illuminated (1 mm of diameter). The interferometer has two arms, equipped with Etalon of different thickness. They aim at the same area of the target. Maximum acquired velocity is 1 km/s or 5 km/s. The maximum time window observable is around 40 ns.

AB asked if this acquisition time can be extended. CB replied that it can be extended by only a few additional ns. The window could be however shifted to match the interesting physics. AB/MT/LP commented that the spall is expected at around 160 ns (as a function of the sample thickness), but it would be interesting to see also the peak velocity (few ns after the impact) with the VISAR.

AB asked who would operate the VISAR. CB replied that no particular support is offered by GSI; the streak camera is relatively simple to operate and does not need additional service.

AB asked about the calibration. PN commented that the calibration is quite easily done by moving the sample few mm to the side. DS commented that for the time calibration the VISAR and PHELIX laser are operated at the same time to check the delay needed to trigger the VISAR. These activities shall be done during the set-up time in the first days of the experiment.

MT proposed that one of the students in GSI come to see the facility before the experiment.

AB asked if there are available sample holders. DS replied that there is a motorized stage in the bottom part of the target chamber that can travel 125 mm up-down, 25 mm left/right/forward/backwards. The sample holder is mounted on a 3×3 in mobile plate. Several holders are already available at GSI, the maximum dimension is determined by the 3×3 in, and the maximum weight is 5kg. On the kinematic mount is also possible to instal different holders. The one available at GSI is shown in Figure 1. The samples can be glued or clamped. Drawings of the holder and set-up will be provided (**Action 9**)

Figure 1: Sample holders installed om the kinematic mount.

AB asked how to position the samples. DS replied that one way is to put two cameras out of the target chamber, use long focal lenses and look at the target from two sides. The cameras are available onsite. Positioning precision is in the order of 50-100 μm. LP commented that the alignment of the laser with the sample (10 mm diameter vs 1 mm laser spot) should not be critical since it is possible to hit in different points and obtain similar results. According to simulations, the most affected area has a radius of about 2 mm. More important is to align the measuring system with laser. DS replied that usually this alignment is done by putting a needle in the middle of the target chamber and align all the diagnostic with the tip of the needle before putting the chamber. Once this alignment is done, it is possible to shot one target after the other.

4 Technical questions

4.1 Z6 Test Station

Q1: How long for the preparatory phase (e.g. chamber mounting, table preparation …)?

A1: DS replied that usually one week is enough but if there is no experiment before it is possible to come in advance to work on the target chamber (without laser).

Q2: Is any safety requirement needed?

A2: General and laser safety course (online)

4.2 Experimental chamber

Q3: Is it compatible with several instruments simultaneously (i.e. VISAR, LDV, High Speed Camera …)?

A3: AB commented that the idea is to have the LDV as VISAR backup, since LDV acquisition time is not limited, and the velocity limitation to 20 m/s can be outworked by moving 1-2mm away from the centre where surface velocities are lower. DS replied that there are many flanges (CL100) available, but for special wavelength it may be necessary to order them. A potential issue is however the fact that the VISAR need to be perpendicular to the target: if also the LDV needs this position they cannot operate simultaneously. AB commented that we may operate a low angle. DS commented that the maximum space between the mirror and the target is around 200 mm. AB asked how much it takes to dismount the VISAR optics; takes 5min, but some hours to put it back. AB asked what other diagnostic tools are typically used when VISAR is operated. PN replied that speed camera is used to record the optical emission, but in our case the target should not be so hot. MT suggest to consider two distinct regimes one with thick and one with thin specimens.

LP commented that if there is no fracture of the sample, the speed decay very fast to zero in less than 1µs. OS commented that the resolution does not allow to pick this signal. It was then concluded that using an LDV is not a viable option, given its limitations in both maximum velocity and sampling frequency.

PN asked about the POLITO VISAR which is fibre-based and it is not limited in the acquisition. LP replied that the range of velocity is wider, but it needs a very reflective surface. PN said that also the GSI VISAR would need at least 100 nm Al, which does not seem compatible with the scope of the experiment.

Q4: Specimen supports

A4: Discussed in Sec. 4.

4.3 GSI VISAR

See Sec. 4.

4.4 POLITO High Speed Camera

Q5: Is it available? Who will operate it?

A5: A high speed camera is available at POLITO and could be possibly used for the experiment, though its technology is not very recent. The Operator should be checked, possibly from POLITO. LP suggested the possibility of a fast-imaging acquisition perpendicular to the laser. It would have lower resolution than shadowgraphy, but useful results may be obtained. It would need high intensity lighting source, as flash lights, installed either outside or inside the chamber. DS commented that there is a port available. POLITO will investigate the feasibility to rent a high speed camera (**action 10**)

4.5 Specimens

Q6: Can we freeze their dimensions (thickness and diameter)?

A6: AB proposed to go ahead with a sample list proposal (see action 3) and start the procurement even before all details about samples, in particular their thickness, are defined on the basis of simulation results; to do so, a larger-than-needed number of samples should be procured, with a relatively large spectrum of dimensions. Concerning the cross-section, based on experience and simulations disks with a diameter of 10 mm seem acceptable.

As to coating of the impacted face, a standard Al coating or cladding can be considered and simulated according to LP to obtain a similar energy deposition for all tested materials. A 1-µm Al coating would be applied to the free face to improve the optical reflectivity of the surface.

5 Logistics questions

5.1 Personnel

Q7: How many persons can/should be simultaneously present at test station?

A7: DN replied at least 3 up to a maximum of 6. Shot from 9am to 6pm, no need of shifts.

Q8: Is it recommended/possible to visit the facility before the test?

A8: Yes, it is highly recommended, as discussed above.

Q9: Who should we include in TNA support request?

A9: At least one person from Rome and one from POLITO (see action 2)

5.2 Material/instrument

Q10: Procurement timeline for specimens (including coatings) to be defined

A10: LP suggested to prepare different set of samples without waiting for all the simulations (few months)

6 List of actions

#	Action	Responsible	Status	Comments
1	Submit application for the TNA before end of June	A. Bertarelli	Completed	Under refereeing process
2	Propose names for TNA application from POLITO, UniRoma and CERN	A. Bertarelli	Completed	Four names included in TNA application
3	Prepare the list of specimens and materials to be tested, including priority ordering	CERN, WWUM, POLITO	Pending	Proposal to be included in the minutes of meeting, including range of dimensions and coating/claddings
4	Define and provide samples of Bulk amorphous alloy and High-entropy alloys	M. Tomut	Pending	BAA and HEA samples already included in preliminary specimens list
5	Prepare TDR for the experiment	All	Pending	To be submitted two months ahead of the experiment, at the latest
6	Organize a visit to GSI-PHELIX in September / October	CERN, WWUM	Pending	Sanitary situation and travel protocols to be taken into account
7	Propose EOS for tested materials in order to complete HELIOS/LS-Dyna simulations	All	Pending	Simulations to be continued at POLITO
8	Provide actual spatial distribution for 1 ns and 5 ns laser pulses with 1mm phase plate	D. Schumacher	Pending	
9	Provide drawings of the sample holder and mounting set-up	P. Neumayer	Pending	
10	Check the possibility to rent and operate a high speed camera	L. Peroni	Pending	

7 Preliminary specimens list

The following list is provisional and may significantly evolve as a function of simulations results, feasibility and availability. If deemed opportune, dimensions may be altered; also spare samples may have different dimensions compared to samples to be shot. The total list of shots is provided for reference; actual number will be substantially reduced as a function of laser availability, simulation predictions and collected results.

Material	Grade	Orientation	Min Ultimate Strenght [MPa]	Coating	Dimensions		Number of samples		
					Ø [mm]	t [mm]	shot	spares	total
Al	TBD		290	no	10	0.25	1	2	3
						0.5	1	2	3
Ta	TBD		760	no	10	0.125	1	2	3
						0.25	1	2	3
Graphite	R4550/R7550	Isotropic	60	1 µm Al	10	2	1	2	3
						1.5	1	2	3
						1	1	2	3
						0.75	1	2	3
Graphite	R4550/R7550	Isotropic	60	Mo HIPIMS	10	1.5	1	2	3
						1	1	2	3
						0.75	1	2	3
Graphite	R4550/R7550	Isotropic	60	Cu HIPIMS	10	1.5	1	2	3
						1	1	2	3
						0.75	1	2	3
MoGr	Nb8304Ng	In-plane	10	1 µm Al	10	2	1	2	3
						1.5	1	2	3
						1	1	2	3
						0.75	1	2	3
MoGr	Nb8304Ng	In-plane	10	6 µm Mo HIPIMS	10	2	1	2	3
						1.5	1	2	3
						1	1	2	3
						0.75	1	2	3
MoGr	Nb8304Ng	In-plane	10	3µm Cu+0.5µm Ti HIPIMS	10	2	1	2	3
						1.5	1	2	3
						1	1	2	3
MoGr	Nb8304Ng	Through-plane	10	no-polished surface?	10	2	1	2	3
						1.5	1	2	3
						1	1	2	3
MoGr	Denser grade	In-plane		1 µm Al	10	2	1	2	3
						1.5	1	2	3
						1	1	2	3
						0.75	1	2	3
MoGr	Denser grade	Through-plane		no-polished surface?	10	2	1	2	3
						1.5	1	2	3
						1	1	2	3
CrGr	MultiMAT	In-plane		1 µm Al	10	2	1	2	3
						1.5	1	2	3
						1	1	2	3
						0.75	1	2	3
CrGr	MultiMAT	Through-plane		no-polished surface?	10	2	1	2	3
						1.5	1	2	3
						1	1	2	3
CFC	FS140	In-plane	10	1 µm Al		2	1	2	3
						1.5	1	2	3
					10	1	1	2	3
CFC	FS140	Through-plane	10	1 µm Al		2	1	2	3
						1.5	1	2	3
					10	1	1	2	3
CuCD	B1000	Isotropic	120	1 µm Al	10	1	1	2	3
						0.75	1	2	3
High Entropy Alloy	TBC	TBC	TBC	TBC	10	1.5	1	2	3
						0.75	1	2	3
	TBC	TBC	TBC	TBC	10	1.5	1	2	3
Bulk Amorphous Alloy						0.75	1	2	3
Grand Total							**54**	**108**	**162**

8 References

1. Seisson, G., Prudhomme, G., Frugier, P. A., Hébert, D., Lescoute, E., Sollier, A., ... & Berthe, L. (2016). Dynamic fragmentation of graphite under laser-driven shocks: Identification of four damage regimes. *International Journal of Impact Engineering*, *91*, 68-79.