**Grant Agreement 871072 WP Technical Report – 2nd reporting period**

**Period: 01 August 2021 (M19) – 31 January 2023 (M36)**

For the second periodical report we need input from you as WP Managers.
**We kindly ask you to formulate a summary of your WP progress for the second reporting period (M19-M36) by the given subjects/questions below.**Please do not repeat reporting the work from the first period (M1-M18). Please report your work in CREMLINplus and in the transition phase towards EURIZON as best as possible.

**The change from CREMLINplus to EURIZON is dated on the 9th April 2022.**
Please report on the given tasks as follow:
 CREMLINplus: 01. Aug. 2021 – 08. Apr. 2022
 EURIZON: 09. Apr. 2022 – 31. Jan. 2023
Please combine the paragraphs (for CREMLINplus and EURIZON) with a linking sentence.

You are free in writing the text. It should be concise and readable. Please write in a clear style, avoiding any abbreviations. Redundancies should be avoided.
Please write your WP technical report in a similar style as your previous reporting from period one. Please use the box below to insert your text. The given subjects/questions give you an idea what is needed. Please try to use the formatting in this template when copy-pasting any text. Thank you.

 **Terminology**
DoA Description of Action (Annex 1 of the GA)
GA Grant Agreement
WP Work package

**Technical Report WP4**

1. **Objectives of WP4** (as described in Annex 1 of the Grant Agreement)
	1. **CREMLINplus: WP4 USSR**

*The Russian Federation plans to extend its capabilities for synchrotron radiation experiments. These plans include the construction of a specialized fourth-generation synchrotron radiation source in Protvino, Moscow Region, as well as a new synchrotron radiation source in Akademgorodok near Novosibirsk. The Protvino source “Ultimate Source for Synchrotron Radiation” (USSR, formerly known as “SSRS-4”) has been chosen as a Russian national flagship project that will be open also for international, especially European utilization. The core of USSR is a 1.3 km diffraction limited storage ring with an electron energy of 6 GeV. The scientific case for the USSR facility shall be further refined, and the intended user community will be developed further. This includes:*

* *Definition of an initial set of about 10 beamlines covering the main techniques in X-ray imaging, diffraction/scattering, and spectroscopy;*
* *Development of USSR in three main areas: infrastructure, accelerator, experiments;*
* *Setting up two international advisory committees, Machine Advisory Committee (MAC) and Scientific Advisory Committee (USSR-SAC);*
* *Conceptual and technical solutions essential for the CDR and TDR will be developed;*
* *R&D for specific technologies as RF-photogun test facility prototype, components and technologies for the electron injection LINAC, beam diagnostics components;*
* *R&D for X-ray optics and special detector systems.*
	1. **EURIZON: WP4 Synchrotrons**

*Light sources are now the most prevalent large-scale research infrastructure in the world. They have become de facto components of the research and innovation ecosystem as international and national level facilities. They provide answers to key societal challenges in areas such as health, the environment, energy and communication, educate the next generation of scientists, engineers and facility managers and administrators, and contribute strongly to the competitiveness of European industry and thus create jobs and wealth. Europe alone counts some 30,000 researchers as its light source user community, covering an unprecedented range of interdisciplinary science, industry and technology.*

*Within Europe, the ESRF Extremely Brilliant Source (ESRF-EBS) is the first high-energy fourth generation synchrotron source that went into operation in August 2020. It is now time that the large body of experience and expertise is shared to the benefit of all the X-ray light sources in Europe. EURIZON, LEAPS (League of Accelerator-Based Photon Sources; www.leaps-initiative.org), and other associate initiative shall constructively promote and ensure the quality and impact of fundamental, applied and industrial research carried out at their facilities.*

*Under the lead of ESRF, the WP partners will further develop and share expertise already achieved in the first half of the project. In the area of machine physics, studies of the beam dynamics and diagnostics, top-up modes, impedance simulations, and beam emittance will be performed. Further studies will investigate vacuum chamber impedances and beam instabilities as well as linear accelerator concepts and components. A concept design for a fully automated x-ray absorption spectroscopy beamline with emphasis on industrial use in catalysis research will be developed, including the description of mail-in services, remote access, and automation. The results of this work package will be of direct benefit for the upcoming 4th generation European synchrotrons, currently under design, namely PETRA IV, but as well other SR sources that have initiated an upgrade such as Elettra, SLS, SOLEIL, and Diamond. Common aspects with FELs will be included where appropriate. The results shall be widely disseminated through the LEAPS (https://leaps-initiative.eu/) initiative, the user community, and industry. in the frame of LEAPS. These actions will further consolidate the positions of X-ray light sources as the most prevalent large-scale research infrastructure in the world, contributing strongly to the competitiveness of European industry and thus create jobs and wealth.*

1. **Overall status**
	1. Please describe the overall status of the WP (e. g. specific achievements/successes of WP; Is the WP overall in line with the Objectives?)

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| *Please describe the overall status of the WP (roughly max. 2000 characters excluding spaces).**Input by WP lead:* |

1. **Tasks and achievements**
	1. We have listed the WP specific tasks as described in the Description of Action (DoA) (Annex 1 of the Grant Agreement (GA)). Please describe the work carried out during the reporting period towards the achievement of the listed tasks and specify by which beneficiary (if possible).
	2. Please name highlights as well as unexpected issues.
	3. Please describe the overlap with other WP or external experts.
	4. Please comment on Deliverables and Milestones achieved so far. (Please find all relevant Deliverables and Milestones for the first reporting period on the last page of this template.)
	5. Please finalize each task with a statement summarizing its status quo. If the task is not on track, please list the task in “5. Deviations” of this template and add the reason for the deviation.
	6. You may also add pictures/diagrams/scientific data (including a title/brief description) – this will be highly appreciated.

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| ***Task 4.1******CREMLINplus: Lattice and systems for the main ring****Please describe the work carried out during the reporting period towards the achievement(roughly max. 1500 characters excluding spaces).**Input by WP task leader (ESRF):*-----------------------------------------***EURIZON: Concepts of 4th generation synchrotron machines in Europe****Please describe the work carried out during the reporting period towards the achievement(roughly max. 1500 characters excluding spaces).**Input by WP task leader (ESRF):*Beam dynamicsDiagnosticsFor beam diagnosis and control of the work package 4.1 focus on the control of the vertical emittance. The underlining concept, successfully implemented for ESRF-EBS, is based on a controlled excitation of the electron beam by a shaker device. This allows the emittance to be stabilised to a pre-defined value. A kick-off meeting was held via zoom and several tasks were defined as shown in table.

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| # | Task/Month | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 |
| 1 | *Define the work organization (M4.1.4)* |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 2 | *Simulation task* |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 3 | *Emittance monitor selection* |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 4 | *Shaker evaluation / selection (M*4.1.*5)* |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 5 | *HW/FW/SW implementation aspects* |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 6 | *Summarize and write the report (*D4.1.3*)* |  |  |  |  |  |  |  |  |  |  |  |  |  |

A three days visit took place in January 2023 during the ESRF restart. The visit allowed to inspect hardware in the EBS tunnel and to further discuss relevant aspects of the implementation of the emittance feedback. SolidWorks drawing of EBS shaker and stripline were observed and analyzed in a common meeting with particular attention to the realization aspects to be addressed for future construction. Comparison studies concerning the best excitation noise to be used for emittance blow up were presented. Also simulations of the emittance blow up with excitation noise as a function of chromaticity were shared and will be applied to the PETRAIV lattice case. These studies show that (for the EBS case) chromaticity above ~3 units are required to have emittance blow up instead of coherent beam oscillations that would result in apparent emittance blow up. Practical demonstration of the use of the vertical emittance feedback took place during the restart activities.  ***Task 4.2******CREMLINplus: Diagnostics and control for the main ring [****deleted in EURIZON****]****Please describe the work carried out during the reporting period towards the achievement(roughly max. 2000 characters excluding spaces).**Input by WP task leader (ESRF):****Task 4.3******CREMLINplus: Vacuum chamber impedances, beam-chamber interactions, instabilities****Please describe the work carried out during the reporting period towards the achievement(roughly max. 1500 characters excluding spaces).**Input by WP task leader (DESY):*-----------------------------------------***EURIZON: Vacuum chamber impedances and beam instabilities****Please describe the work carried out during the reporting period towards the achievement(roughly max. 1500 characters excluding spaces).**Input by WP task leader (DESY):****Task 4.4******CREMLINplus: Top-up Linac development including RF-guns and diagnostics system****Please describe the work carried out during the reporting period towards the achievement(roughly max. 1500 characters excluding spaces).**Input by WP task leader (INFN):*-----------------------------------------***EURIZON: Linac development****Please describe the work carried out during the reporting period towards the achievement(roughly max. 1500 characters excluding spaces).**Input by WP task leader (INFN):****Task 4.5******CREMLINplus: Photogun prototype, its beam diagnostics and RF systems****Please describe the work carried out during the reporting period towards the achievement(roughly max. 1500 characters excluding spaces).**Input by WP task leader (DESY):*-----------------------------------------***EURIZON: Photogun prototype & beam diagnostics****Please describe the work carried out during the reporting period towards the achievement (roughly max. 1500 characters excluding spaces).**Input by WP task leader (DESY):****Task 4.6******CREMLINplus: Scientific case, beamlines and experimental stations: definition of perspective techniques for a 4th generation source****Please describe the work carried out during the reporting period towards the achievement(roughly max. 1500 characters excluding spaces).**Input by WP task leader (DESY):*-----------------------------------------***EURIZON: Development of a generic Conceptual Design Report for automated X-ray Absorption Spectroscopy Beamlines****Please describe the work carried out during the reporting period towards the achievement(roughly max. 1500 characters excluding spaces).**Input by WP task leader (DESY):****Task 4.7******CREMLINplus: Support strategic coordination of USSR [****deleted in EURIZON****]****Please describe the work carried out during the reporting period towards the achievement(roughly max. 2000 characters excluding spaces).**Input by ESRF, DESY, European XFEL, INFN* |

1. **Outlook**

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| *Please give a short outlook on the next steps and upcoming tasks (roughly max. 1000 characters excluding spaces).**Input by WP task leaders:*WP4.1 is advanced compared to schedule. The simulations and the choice of shaker for vertical emittance blow up feedback will continue following the present schedule. |

1. **Deviations from Annex 1 & 2 of Grant Agreement**
* Explain the reasons for any deviations from the DoA, the consequences and the proposed corrective actions.
* Include explanations for tasks not fully implemented, critical objectives not fully achieved and/or not being on schedule. Explain also the impact on other tasks, on the available resources and the planning.
* [ ]  Not applicable

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| *Please insert your text here (roughly max. 2000 characters excluding spaces).**Input by WP task leaders:* |

1. **Critical Risks**
* In Annex 1 of the Grant Agreement we have identified potential risks for your WP. Please find below the foreseen risks stated in the Grant Agreement.
* If the risk materialized, please formulate a statement which risk-mitigation measures you have applied.

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| ***Description of Risk****: CREMLINplus: Conceptual design phase:** *Incorrectly selected alternatives for final solutions,*
* *Lack of information or information transfer on USSR project objectives*
* *Insufficient link to the USSR project organisation,*
* *Insufficient use of experience and knowledge gained at other synchrotron projects,*
* *Insufficient risk assessment on environmental and geophysics conditions of the planned site*

***Proposed Risk-Mitigation Measures:*** *• Regular meetings including USSR decision makers** *Ensure participation of international experts in USSR meetings, e.g by teleconferences,*
* *Close coordination with the USSR project management and the international advisory committees (SAC, MAC)*
* *Participation in international conferences with the presentation of the approaches used and the results obtained.*

**Did you apply the risk-mitigation measures?** [x]  **YES** [x]  **NO****Did the risk materialize?** [x]  **YES** [x]  **NO***Please add your comments here. If the risk-mitigation measures couldn't be applied, please explain why (roughly max. 1000 characters excluding spaces).**Input by WP task leaders:* |

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| ***Description of Risk****: CREMLINplus: Detailed design phase:** *Insufficiently estimated or incomplete designs,*
* *Difficulties to reach specifications*
* *Insufficient level of integration of various systems and changes/adjustments in design & technical specifications of USSR*

***Proposed Risk-Mitigation Measures:*** *• Regular comparison of the USSR project, its specifications and standards with similar projects and / or their elements,* * *Benchmarking with ESRF-EBS*
* *Regular meetings and close coordination of partners with the USSR design and construction teams.*

**Did you apply the risk-mitigation measures?** [x]  **YES** [x]  **NO****Did the risk materialize?** [x]  **YES** [x]  **NO***Please add your comments here. If the risk-mitigation measures couldn't be applied, please explain why (roughly max. 1000 characters excluding spaces).**Input by WP task leaders:* |

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| ***Description of Risk****: Simulations: no real improvement from optimizations**Simulations: code is not sufficiently robust or flexible for use by both laboratories directly involved and/or other SR laboratories**Experiment: Testable SR solutions found too late to schedule test with beam**Personnel: lack of manpower* ***Proposed Risk-Mitigation Measures:*** *Continuously monitor progress and make adjustments where necessary, apply adequate mitigation measure early* **Did you apply the risk-mitigation measures?** [x]  **YES** [x]  **NO****Did the risk materialize?** [x]  **YES** [x]  **NO***Please add your comments here. If the risk-mitigation measures couldn't be applied, please explain why (roughly max. 1000 characters excluding spaces).**Input by WP task leaders:* |

1. **Unforeseen Risks** *(if applicable)*
* Did an unforeseen risk arise during the first period?
* If so please describe the risk and the risk-mitigation measures you have applied.

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| ***Description of Risk****: ……………………………****Proposed Risk-Mitigation Measures:*** *…………………………..**Please add your comments here. If the risk-mitigation measures couldn't be applied, please explain why (roughly max. 1000 characters excluding spaces).**Input by WP task leaders:* |

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| ***Description of Risk****: ……………………………****Proposed Risk-Mitigation Measures:*** *…………………………..**Please add your comments here. If the risk-mitigation measures couldn't be applied, please explain why (roughly max. 1000 characters excluding spaces).**Input by WP task leaders:* |

**Deliverables and Milestones 2nd Reporting Period**

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| **WP4 Synchrotrons: Deliverables** |
| **Relative Number in WP** | **Number** | **Name** | **Lead Beneficiary** | **Type** | **Dissem-ination level** | **Due date (in months)** | **Status** |
| D4.22 | D102 | Report on the 1st International workshop | ESRF | R | PU | 36 |  |

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| **WP4 Synchrotrons: Milestones** |
| **Number** | **Name** | **Lead Beneficiary** | **Due Date (in months)** | **Description** | **Work Package No.** | **Status** |
| M51 | Identify common beam physics interests, define necessary software developments | DESY | 30 | Common beam physics interests identified, necessary software developments defined | 4 | reached |
| M52 | Definition of the work organization for beam dynamics studies | DESY | 30 | Work organization for beam dynamics studies defined | 4 | reached |
| M53 | Define work organization and contributors to the tasks identified in M51 | ESRF | 32 | Work organization and contributors to the tasks identified in M51 defined | 4 | reached |
| M54 | Definition of the work organization for beam diagnostics studies | DESY | 36 | Work organisation for beam dynamics done | 4 |  |
| M55 | Selection of the shaker device | ESRF | 42 | Selection of the shaker device done | 4 |  |
| M56 | Release of a software for analytical and numerical studies of the beam instabilities in synchrotrons | DESY | 48 | Software for analytical and numerical studies of the beam instabilities in synchrotrons released | 4 |  |
| M57 | Simulation codes benchmark completed  | INFN | 40 | Simulation codes benchmark completed | 4 |  |
| M58 | Optimized procedure for precise and reliable phase space measurements at high brightness photoinjectors established, release of software | DESY | 48 | Optimized procedure for precise and reliable phase space measurements at high brightness photoinjectors established, release of software | 4 |  |
| M59 | Input collection finalized | DESY | 41 | Input from the 1. International workshop (see D102) analysed | 4 |  |