**Table 3.1b: Work package description** *(follow max page limit)*

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| --- | --- | --- | --- | --- | --- | --- |
| **Work package number** | WP 5 | | **Lead beneficiary** | | | BINP |
| **Work package title** | Joint technology development around SCT and future lepton colliders | | | | | |
| **Participant number\*** |  |  | |  |  |  |
| **Participant short name** | CERN | BINP | | CNRS | INFN | JLU |
| **Person-months per participant²**  **requested by EC** | 18 | 0 | | 18 | 84 | 24 |
| **Total Person-months per participant1** | 18 | Large | | 18 | 168 | 24 |
| **Start month** | 1 | | | | **End month** | 48 |

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| **Objectives (*CREMLIN*):**   * To support and develop EU and Russian scientific cooperation in the SCT project * To make an example of good practice on establishing collaboration around Russian RI with extensive participation of EU institutions * To support joint EU – Russian efforts on development of future lepton colliders * To increase visibility of SCT project in EU and world-wide scientific and decision-makers communities |

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| **Description of work**  **Task 5.1: Fostering internationalization and visibility of the SCT project, support of outreach activities related to SCT (BINP, CERN, INFN).**  **M1-M48**  **Aim of this task is to support efforts devoted to promotion of SCT project in Europe and world-wide; to foster the formation of collaboration around the SCT detector and the accelerator-detector interface with active involvement of European research organizations. The CREMLIN project facilitated Russian – EU interactions around the SCT project. These interactions will be extended and intensified within the framework of the CREMLINplus project. Particularly,** an international collaboration around the SCT detector is going to be formed and formally established; critical decisions on the SCT detector design, particle detection technologies, electronics and data processing are going to be made by the collaboration. Researchers and institutions involved in the R&D activities for the SCT detector at an early stage are supposed to compose a basis for the collaboration.  **Annual international workshops of SCT are held, including the kickoff meeting of the formally established collaboration around the SCT detector. These workshops are needed to make the progress of the SCT project visible, to attract new partners, and to discuss new ideas on the physics case of experiment.**  Outreach activities on SCT are part of the objectives, e.g. within task 5.1, multimedia material on the SCT particle injector, collider, detector and physics case will be created.  **Task 5.2: Development of collider technologies and fostering synergy between SCT, CLIC, and FCC-ee collider projects (CERN, BINP, LAL-CNRS).**  **M1-M48**  This task is devoted to interactions between Russian and the European collider expert communities. The international context and expertise of the CERN community is a perfect basis for a joint design and development of the machine-detector interface (MDI) and final focus area of SCT. This activity exploits synergies between the SCT project and the future electron-positron colliders CLIC and FCC-ee under development at CERN.  The second direction of cooperation is joint development of accelerator equipment by LAL-CNRS and BINP groups:   * Development of the electron RF photo-gun with low emittance and high flux electron beam. Production of key elements. * Development of the polarized electron source. Production of key elements and systems. * Development of magnet technologies, production and measurement of accelerator magnets.   **Task 5.3: Development of software for the design of an SCT detector (BINP, CERN).**  **M1-M48**  The design of a detector for SCT requires the simulation, reconstruction and analysis of physics in multiple sub-detector options. For this purpose, a flexible software is a key tool for making motivated decisions about the detector design and for choosing among different subsystem options. The software will be based on Gaudi (overall framework), Geant4 (interactions and energy deposits of particles in the detector layers) and ROOT (data analysis and statistical interpretation) and on the DD4hep (flexible detector geometry description toolkit developed in the AIDA and AIDA2020 EU projects). Establishing the use of a distributed computing framework based on DIRAC will also allow the seamless transnational access to computing resources.  **Task 5.4: Development and design of Inner Tracker for the SCT detector (BINP, INFN).**  **M1-M48**  The aim of this task is to foster efforts of international community on R&D around the inner tracker of the SCT detector. Two prototypes for the inner tracker (IT) – compact TPC with MPGD readout and cylindrical µ-RWELL (C-RWELL) chamber – are going to be developed and tested in close collaboration of BINP, INFN LNF, and INFN Ferrara groups.  The C-RWELL is a very low material budget (1% X0) full cylindrical IT based on the innovative µ-RWELL technology, proposed by the Ferrara and LNF INFN groups. Both teams have long been involved in the R&D, design and manufacture of MPGDs for high energy physics experiments. In particular they have been involved in the development of both planar GEM (LHCb) as well as Cylindrical-GEM detectors for the Inner Tracker of the KLOE experiment (LNF), and BESIII (Ferrara).  The C-RWELL will exploits several innovative concepts (“openable detector”, “floating-amplification”, “reversed conical hole-shape”) that make the C-RWELL a highly reliable and performing IT, while the spark suppression mechanism, intrinsic to the µ-RWELL technology, make the operation of this detector in harsh environment more safe with respect to other MPGD based devices. In addition, the C-RWELL, able to stand particle fluxes above 1 MHz/cm2, operated in micro-TPC mode, exhibits an excellent spatial resolution (down to 40-60 µm over a wide track incidence angular range, 0-45°). The development of some components of the C-RWELL, such as the resistive amplification stage and the readout plane, will be performed in collaboration with several Companies specialized in the photolithography of flexible (polyimide) and rigid Printed Circuit Board technology as well as the magnetron sputtering of Diamond Like Carbon (DLC).  The C-RWELL project foresees the following main steps:   1. Design of the mechanics, readout electrodes and amplifications stage of the detector 2. Design of the construction toolings (cylindrical molds) and modification of the assembly/insertion tool 3. Construction of the prototype 4. Integration with front-end electronics 5. Characterization of the fully equipped prototype with cosmic rays and in beam tests   **Task 5.5: Development and design of Central Tracker for the SCT detector (BINP, INFN).**  **M1-M48**  The aim of this task is to foster efforts of the international community on R&D around central tracker of the SCT detector. A prototype for drift chamber (DC) is going to be developed and tested by groups from INFN Lecce, INFN Bari and BINP.  TraPId (Tracking and Particle Identification), the Central Tracker proposed by the Bari and Lecce INFN groups for the detector at SCT is an ultra-light drift chamber equipped with cluster counting/timing readout techniques. Main peculiarities of this design are the high transparency in terms of multiple scattering contribution to the momentum measurement of charged particles and the very precise particle identification capabilities.  TraPId is a down sized drift chamber from the larger one designed for the IDEA detector at both FCC-ee and CEPC, the proposed future circular e+e- colliders. It is inspired by the original design of the KLOE drift Chamber, successfully operated at the Daphne facility of the Frascati INFN Laboratories during the last 20 years and culminated with the construction of the MEG2 drift chamber, which is currently under commissioning at the PSI laboratories in Zurich.  The TraPId R&D program spans over three different topics.   1. Mechanical design of the drift chamber end plates with a novel tension recovery scheme to minimize the amount of material in front of the end-plate crystal calorimeter. 2. Development of a new type of field wires based on carbon monofilaments coated with a thin metal sheet to allow for ease of soldering. 3. Development of a fast digitizer coupled to a FPGA for fast filtering and pre-analysis of the signal spectra, aiming at strongly reducing the amount of data transfer.   **Task 5.6: Development and design of a Particle Identification system for the SCT detector (BINP, JLU)**  **M1-M48**  The particle identification system is a key system of the SCT detector. Particle identification (PID) systems based on Cherenkov detectors are widely used in HEP experiments to discriminate between charged long-living particles. Today the most promising types of Cherenkov detectors for the identification of particles with about 1 to 10 GeV/c momentum are based on the ring imaging technique using quartz or aerogel radiators and focusing designs. Notable representatives of such kind of detectors are the FDIRC (Focusing Detection of the Internally Reflected Cherenkov light) and the FARICH (Focusing Aerogel Ring Imaging Cherenkov detector) designs. Registration of single Cherenkov photons with a position resolution of about 1 mm is needed in these detectors. Excellent resolution of photon arrival time (about 100 ps) and low dead time are also required for improving PID and suppressing the high rate of background hits that are typical in modern experiments. Also, the ageing of photon sensors with high counting rate and radiation damage can be an issue.  The multipurpose detector to be built should have PID subdetectors in the front and back endcaps and in the barrel region. The experience of several research groups will be combined to come up with proposals for the optimum PID system for the SCT project with respect to performance and cost. Detector prototypes are going to be constructed and tested to verify the performance of these novel detector concepts and their readout systems. |

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| **Deliverables** *(brief description and month of delivery)*  D5.1 M18. **Status report on the software for the SCT detector**. This report will describe status of the software for the design of the SCT detector with a focus on the geometry implementations for the different subsystem options.  D5.2 M24. **Status report on R&D work on Inner Tracker for the SCT detector**. This report is supposed to describe joint EU – Russia activities around inner tracker of the SCT detector  D5.3 M24. **Status report on R&D work on Central Tracker for the SCT detector**. This report is supposed to describe joint EU – Russia activities around central tracker of the SCT detector  D5.4 M24. **Status report on R&D work on Particle Identification system for the SCT detector**. This report is supposed to describe joint EU – Russia activities around PID system of the SCT detector  D5.5 M36. **Report on joint development of collider technologies for lepton colliders**. This report will describe joint activities of BINP, CERN and LAL-CNRS groups in lepton colliders.  D5.6 M44. **Final report on the software for the SCT detector**. This report will describe advanced stage of SCT detector simulation including implications for the SCT physics case and comparison of different options of SCT detector subsystems.  D5.7 M44. **Final report on R&D work on Inner Tracker for the SCT detector**. This report is supposed to describe the advanced stage of activities of SCT collaboration related to inner tracker of the SCT detector, including the construction and test of prototype.  D5.8 M44. **Final report on R&D work on Central Tracker for the SCT detector**. This report is supposed to describe the advanced stage of activities of SCT collaboration related to central tracker of the SCT detector, including the construction and test of prototype.  D5.9 M44. **Final report on R&D work on Particle Identification system for the SCT detector**. This report is supposed to describe the advanced stage of activities of SCT collaboration related to PID system of the SCT detector, including the construction and test of prototype. |

\*will be filled in by coordinator when the list of beneficiaries is final;

1 Person months in total by participant including requested and in-kind

² Person months for which fund is requested by EC

**Table 3.1c: List of Deliverables** *(outside of page limit)*

*Deliverables can be a report on the developed device, a workshop, a prototype,*

*not more than 1-2 per task*

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| **Del. no.1** | **Deliverable name** | **WP no.** | **Short name of lead participant** | **Type2** | **Dissemination level3** | **Delivery date4** |
| 5.1 | **Status report on the software for the SCT detector** | 5 | CERN | R | PU | 18 |
| 5.2 | **Status report on R&D work on Inner Tracker for the SCT detector** | 5 | INFN | R | PU | 24 |
| 5.3 | **Status report on R&D work on Central Tracker for the SCT detector** | 5 | INFN | R | PU | 24 |
| 5.4 | **Status report on R&D work on Particle Identification system for the SCT detector** | 5 | JLU | R | PU | 24 |
| 5.5 | **Report on joint development of collider technologies for lepton colliders** | 5 | LAL-CNRS | R | PU | 36 |
| 5.6 | **Final report on the software for the SCT detector** | 5 | BINP | R | PU | 44 |
| 5.7 | **Final report on R&D work on Inner Tracker for the SCT detector** | 5 | BINP | R | PU | 44 |
| 5.8 | **Final report on R&D work on Central Tracker for the SCT detector** | 5 | BINP | R | PU | 44 |
| 5.9 | **Final report on R&D work on Particle Identification system for the SCT detector** | 5 | BINP | R | PU | 44 |

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1 Deliverable numbers in order of delivery dates. Please use the numbering convention <WP number>.<number of deliverable within that WP>. For example, deliverable 4.2

would be the second deliverable from work package 4.

2 Please indicate the nature of the deliverable using one of the following codes:

R = Report,

DEM = Demonstrator,

DEC= websites, patents, press & media actions,…

Other = software, technical diagram….

3 Please indicate the dissemination level using one of the following codes:

PU = Public, fully open via e.g. web

CO = Confidential, only for members of the consortium (including the Commission Services).

CI = classified, information as referred to in Commission Decision 2001/844/EC.

4 Measured in months from the project start date (month 1).

**Table 3.2a: List of Milestones** *(outside of page limit)*

*‘Milestones’ means control points in the project that help to chart progress. Milestones*

*may correspond to the completion of a key deliverable, allowing the next phase of the*

*work to begin. They may also be needed at intermediary points so that, if problems have*

*arisen, corrective measures can be taken. A milestone may be a critical decision point in*

*the project where, for example, the consortium must decide which of several technologies*

*to adopt for further development.*

*Not more than 1-2 per task*

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| --- | --- | --- | --- | --- |
| **Mile no.** | **Milestone name** | **Related Work package(s)** | **Due date1** | **Means of verification2** |
| 1 | Release of the software framework for SCT detector | 5 | 18 | Conference contribution |
| 2 | Kick-off meeting of collaboration around the SCT detector | 5 | 18 | On-line publication |
| 3 | Collider prototype with high beam current | 5 | 42 | Conference contribution |
| 4 | Construction and test of the inner tracker (C-RWELL and Compact TPC) prototype for SCT detector | 5 | 40 | Conference contribution |
| 5 | Construction and test of the drift chamber prototype for SCT detector | 5 | 42 | Conference contribution |
| 6 | Prototype for PID system of the SCT detector | 5 | 42 | Conference contribution |

1 Measured in months from the project start date (month 1).

2 Show how you will confirm that the milestone has been attained. Refer to indicators if appropriate. For example: a laboratory prototype completed and running flawlessly; software released and validated by a user group; field survey complete and data quality validated.

**Table 3.2b: Critical risks for implementation** *(outside of page limit)*

*A critical risk is a plausible event or issue that could have a high adverse impact on the ability of the project to achieve its objectives.*

*The risk level is the estimated probability that the risk will materialise even after taking account of the mitigating measures put in place.*

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| **Description of risk** | **WP (s)**  **involved** | **Proposed risk-mitigation measures** | **Risk level**  High medium, low |
| Wide internalization of the SCT or of any other project can be limited by the current economic and political instability in the relations between the countries. | 5 | Development of special agreement between governments could regulate all aspects of scientific communication especially related to the project and might be able to solve most part of potential risks. | Low |
| R&D of the SCT detector subsystems is a very challenging business. There is always a probability of not achieving the expected parameters to fit the physics program or collider conditions | 5 | To minimize possible effect of these risks at least two options for each SCT detector subsystems are to be developed | Medium |
| Mass production of the novel detector technologies could be limited by modern state of the high-tech industry: aerogel production, carbon fibres, photolithography on polyimide substrates, DLC sputtering, metal coating of carbon monofilament, SiPMs and other front-end electronics with good enough radiation tolerance. | 5 | Throughout the R&D activities it is necessary to look for reliable industrial partners for mass production of detector components and to produce some small trial batches of component materials to determine the most part of the potential mass production risks. | High |

Does a participant envisage that part of its work is performed by linked **third parties** Y/N?

If Y: which part to which third party (fill in a separate table 3.4b for each third party)

**Background information needed for chap 1-2 of the proposal**

*(outside of page limit)***:**

|  |  |
| --- | --- |
| **How does this work-topic fit the specific selection criteria for this proposal?** | |
| **1. How does the WP strengthen the structured cooperation between Russia and European RIs community?** | Activities around SCT will strengthen the existing cooperation and foster establishing new joint activities involving European and Russian research institutions. |
| **2. Which impact will the joint development have on the Russian community** | The joint development serves as a platform for identification of competences between European and Russian partners that are required for implementation of the RI projects. |
| **3. Which impact will the joint development have on the European community** | The structured cooperation between European and Russian partners exploits synergies across project and Research Infrastructures and will thereby strengthen links. |
| **4. Which impact will the WP have on internationalization beyond Europe?** | The successful joint European – Russian efforts around SCT will foster interest of the world-wide scientific community and will attract new resources to the SCT project. |
| **5. Does the WP contribute to harmonization of procedure and framework conditions for access? If yes how?** | A clear procedure and conditions of access should be established for SCT. Activities around SCT will foster establishing similar standards for other Russian RIs. |
| **6. How does the WP promote participation of Russian researchers in EU projects?** | Communications triggered by joint development around SCT will improve knowledge of EU projects in Russian scientific and other communities. |
| **7. Does the WP improve access of European Scientists to Russian RIs?**  **How?** | The WP under the SCT project is to improve access of European scientists to Russian RIs. Apart from this, communications triggered by the joint development around SCT will expand the recognition of the Russian RIs capabilities among EU scientific and other communities. |
| **8. Will there be an impact on industry and/or development of ERA?** | Development of SCT will set new challenges for high-tech industry. |
| **9. Identify other relevant funding initiatives and describe how this WP is complementary to them.** | Work on scientific and technological background for SCT is supported by a set of projects funded by the Russian Ministry of Science and Higher Education within the framework of the State Programs as well as by several grants provided by Russian science foundations.  As part of the activities provided for in the Implementation Plan for the Strategy for Scientific and Technological Development of the Russian Federation and the passport of the national project “Science”, it is planned to focus on the concentration of public resources by supporting the most successful research teams and the most ambitious (and dynamically developing) projects, including substantial international participation.  Implementation of WP5 of CREMLINplus will contribute to the formation of an international center of competence in Novosibirsk, which is a prerequisite for deciding on the transition to the implementation phase of the SCT project. |