Work package number [9]	WP5	**Lead beneficiary** [10]	2 - BINP
Work package title	SCT - Joint technology development around SCT and future lepton colliders		
Start month	1	**End month**	48

Objectives

Aim of this task is to support efforts devoted to promotion of the SCT project in Europe and world-wide
- 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

Description of work and role of partners

WP5 - SCT - Joint technology development around SCT and future lepton colliders [Months: 1-48]
BINP, JLU, CNRS, INFN, CERN
Task 5.1: Fostering internationalization and visibility of the SCT project, support of outreach activities related to SCT (BINP, CERN, INFN) M1-M48
An international collaboration around the SCT detector is going to be formed and formally established based on first initiatives during CREMLIN; 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 for SCT are held including an enhanced kick-off meeting of the formally established collaboration around the SCT detector including instututions outside of CREMLINplus. 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 planned and 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, CNRS-LAL) 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 CNRS-LAL 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. A particularly important issue is the choice of the base technology of the inner tracker for the SCT detector.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 INFN-LNF 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 exploit 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 safer 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°). Some components of the C-RWELL, such as the resistive amplification stage and the readout plane, will be developed involving expertise 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.

Participation per Partner

Partner number and short name	WP5 effort
2 - BINP	48.00
18 - JLU	24.00
23 - CNRS	18.00
29 - INFN	84.00
31 - CERN	18.00
Total	192.00

List of deliverables

Deliverable Number[14]	Deliverable Title	Lead beneficiary	Type[15]	Dissemination level[16]	Due Date (in months)[17]
D5.1	Status report on the software for the SCT detector	31 - CERN	Report	Public	18
D5.2	Status report on R&D work on inner tracker for the SCT detector	29 - INFN	Report	Public	24
D5.3	Status report on R&D work on central tracker for the SCT detector	29 - INFN	Report	Public	24
D5.4	Status report on R&D work on particle identification system for the SCT detector	18 - JLU	Report	Public	24
D5.5	Report on joint development of collider technologies for lepton colliders	23 - CNRS	Report	Public	42
D5.6	Final report on the software for the SCT detector	2 - BINP	Report	Public	44
D5.7	Final report on R&D work on inner tracker for the SCT detector	2 - BINP	Report	Public	44
D5.8	Final report on R&D work on central tracker for the SCT detector	2 - BINP	Report	Public	44
D5.9	Final report on R&D work on particle identification system for the SCT detector	2 - BINP	Report	Public	44

Description of deliverables

D5.1 Status report on the software for the SCT detector (M18)
D5.2 Status report on R&D work on inner tracker for the SCT detector (M24)

D5.3 Status report on R&D work on central tracker for the SCT detector (M24)
D5.4 Status report on R&D work on particle identification system for the SCT detector (M24)
D5.5 Report on joint development of collider technologies for lepton colliders (M42)
D5.6 Final report on the software for the SCT detector (M44)
D5.7 Final report on R&D work on inner tracker for the SCT detector (M44)
D5.8 Final report on R&D work on central tracker for the SCT detector (M44)
D5.9 Final report on R&D work on particle identification system for the SCT detector (M44)

D5.1 : Status report on the software for the SCT detector [18]

Status report on the software for the SCT detector

D5.2 : Status report on R&D work on inner tracker for the SCT detector [24]

Status report on R&D work on inner tracker for the SCT detector

D5.3 : Status report on R&D work on central tracker for the SCT detector [24]

Status report on R&D work on central tracker for the SCT detector

D5.4 : Status report on R&D work on particle identification system for the SCT detector [24]

Status report on R&D work on particle identification system for the SCT detector

D5.5 : Report on joint development of collider technologies for lepton colliders [42]

Report on joint development of collider technologies for lepton colliders

D5.6 : Final report on the software for the SCT detector [44]

Final report on the software for the SCT detector

D5.7 : Final report on R&D work on inner tracker for the SCT detector [44]

Final report on R&D work on inner tracker for the SCT detector

D5.8 : Final report on R&D work on central tracker for the SCT detector [44]

Final report on R&D work on central tracker for the SCT detector

D5.9 : Final report on R&D work on particle identification system for the SCT detector [44]

Final report on R&D work on particle identification system for the SCT detector

Schedule of relevant Milestones

Milestone number[18]	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
MS1	Kick-off Meeting	1 - DESY	2	Meeting took place
MS4	Annual General Assembly Meeting after Year 2 realised, including status of achieved synergy (technical / non-technical activities and objectives) among all WP	1 - DESY	24	Minutes of GA Year 2 meeting
MS5	Annual General Assembly Meeting after Year 3 realised, including status of achieved synergy (technical / non-technical activities and objectives) among all WP	1 - DESY	36	Minutes of GA Year 3 meeting
MS26	Release of the software framework for SCT detector	2 - BINP	18	Conference contribution

Schedule of relevant Milestones

Milestone number[18]	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
MS27	Kick-off meeting of international collaboration around the SCT detector	2 - BINP	18	Meeting organised
MS28	Construction and test of the inner tracker /C-RWELL and compact TPC) prototype for SCT detector	2 - BINP	40	Conference contribution
MS29	Collider prototype with hight beam current	2 - BINP	36	Conference contribution
MS30	Construction and test of the drift chamber prototype for SCT detector	2 - BINP	42	Conference contribution
MS31	Prototype for PID system of the SCT detector	2 - BINP	42	Conference contribution