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Heavy-flavour production in relativistic heavy-ion collisions and development of novel generation of extra-low-material-budget Vertex Detectors for future experiments at CERN and JINR

One of the key requirements to be met by the future experimental installations like ALICE is to increase the accuracy of secondary vertices reconstruction in order to meet the challenging task of high precision studies in relativistic heavy-ion collisions of such rare processes like heavy-flavour production. This task requires the further reduction of the existing values of material budget of the Inner Tracking System and it is one of the main goals of the ALICE upgrade during the Long Shutdown 3 (LS3) in the period 2023-2024. The Inner Tracking System (ITS2) –the main vertex detector of ALICE –already has the record level of 0.3% radiation length (X/Xo) per layer. The new task is the development of a new high granularity fast detector which will be capable to ensure X/Xo below of 0.05% per layer. This challenge of development of high precision Vertex Detector is relevant not only to ALICE but to all experimental HEP installations both in Europe and Russia.

The proposal of the ALICE/ITS Collaboration, aimed at the R&D of the Ultra Lightweight Vertex Detector for the future ITS3 to be installed after the LS3, was developed recently and the Saint-Petersburg State University team is one of the participants. This Ultra Lightweight Vertex Detector will consist of ultra-thin (˜20 m) silicon sensors with MAPS technology, arranged in perfectly cylindrical layers, featuring an unprecedented low material budget of 0.05% X0 per layer. The given task is also paving the way for the construction of a new all-silicon tracker with unprecedented low mass, that would allow reaching down to an ultra-soft region of the phase space and to measure the production of very-low transverse momentum lepton pairs, photons and hadrons at the LHC after Long Shutdown 4 (LS4). Among the real strong challenges to be met are the design and development of the extra-lightweight, state-of-the-art support structures capable to ensure the high level of thermo- and mechanical- stability of the large arrays (of many square meters) of these ultra-thin silicon sensors. Another challenge is the efficient, very low speed, gas cooling system that will provide the functionality of these MAPS sensors.

The implementation of these advanced detector and carbon fiber composite technologies to the vertex trackers will also expand considerably the heavy-flavour research physics programs at the fixed-target NA61/SHINE at the SPS, during the LS2 in 2019-2021, and to the future BM@N, MPD and SPD experiments at NICA collider at JINR.

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