Referee report

on the project "Physics studies at the CMS experiment and second phase of detector upgrade for operation in high luminosity conditions".

JINR physicists have been involved in the implementation of the CMS experiment since the very beginning when they took responsibilities for the design, construction, commissioning, operation and upgrade of the Endcap Hadron Calorimeter and First Forward Muon Station ME1/1. During the long shutdowns of the LHC, LS1 and LS2, the JINR team made a significant contribution to the first phase of the CMS upgrade, aimed at ensuring efficient operation of the detectors at luminosities up to 2×10^{34} cm^{-2} s^{-1} in *pp*-collisions at the highest possible LHC energy.

JINR researchers also take an active part in the implementation of the physical research program. The physics research of the JINR team is focused on the study of the Higgs boson properties, tests of the Standard Model and searches for new physics beyond the SM. The team has already published many interesting results on these topics using data collected during RUN1 and RUN2 of the LHC operation. Among the recent results it is worth noting the limits obtained in the search for new physics (production of Z', graviton, etc.) in two-lepton events. In this analysis, model-independent upper limits on the production of heavy resonances were established. This work will be continued and expanded to search for long-lived particles predicted in theoretical scenarios with dark matter, SUSY, baryogenesis and others. Precision tests of the SM will remain an important task for the JINR group.

The LHC luminosity will start to increase up to $7.5\times10^{34}cm^{-2}c^{-1}$ after LS3 shutdown in 2030. This will result in high pileup (140-200 events per bunch crossing) and harsh radiation environment and will require an upgrade of the CMS detectors for operation in high-luminosity HL–LHC conditions. To ensure effective operation of CMS detectors and meet HL-LHC requirements, the CMS phase-2 upgrade will start in mid-2026 and continue until 2030. JINR contribution to the CMS phase-2 upgrade focuses on development of the High Granularity Calorimeter (HGCal) and the upgrade of the ME1/1 detectors.

The HGCAL will replace the existing CMS endcap calorimeters for the HL-LHC era. It is a sampling calorimeter with ~ 6 million silicon sensor channels and ~ 4 thousand scintillator tiles readout with on-tile silicon photomultipliers. In addition to the energy and position of the energy deposits, the HGCAL will measure the time of their arrival with the order 50 ps precision. The JINR group plans to contribute to the development and construction of an experimental complex for testing the HGCAL cassette with sensor elements and participate in the assembly and testing of the cassettes. The group will also take part in the development of a prototype of the HGCAL low-voltage power supply system and its integration into the experimental setup.

A substantial part of phase-2 Endcap Muon system upgrade was already done by JINR during LS2 period. Inner rings of CSC chambers (132 chambers) were equipped with new fast electronics and power system. A new cooling system was also installed on ME1/1 CSCs.

During LS3 shutdown, the chambers of the first muon station (216 chambers in total) will be dismantled and transferred to a specially created laboratory area, where they will be refurbished and partially upgraded. JINR is responsible for redesigning and construction of 36 ME1/1 patch panels, manufacturing new high voltage cables, new loading machines for CSC installation, cables and services integration. The JINR group will perform an upgrade of the chambers and their commissioning, including tests with cosmic rays. The R&D will continue to study the physical characteristics of the detectors - their stability, efficiency and durability under high background conditions.

The characteristics of CSC chambers under irradiation were investigated at the GIF++ facility at CERN. It is unclear from the description of the presented project whether the corresponding study was carried out for silicon sensors and scintillators of the HGCal calorimeter, considering the high fluence (above 10^{16} n_{eq}/cm^2) and the diversity of showers. Is it envisaged to replace the part of the sensors closest to the beam?

The JINR group will contribute to the development of event reconstruction algorithms and software for distributed data processing and analysis systems based on grid technologies. Stable operation of the JINR grid infrastructure for the CMS experiment of the Tier-1 and Tier-2 centers, which are widely used for processing and storing CMS data, is an important objective of the project.

JINR's participation in the LHC experiments is part of the Institute's long-term commitments and is envisaged in the 7-year JINR Development Plan for 2024-2030. The requested resources, including the costs of staff stay at CERN, are adequate to the objectives of the project "Physics studies at the CMS experiment and second phase of the detector upgrade for operation at high luminosity conditions". I recommend accepting the project for the period 2026-2030 with the highest priority.

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