## **Referee report on the Project CMS (JINR participation)**

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The report submitted to the JINR PAC for Particle Physics covers the participation of physicists and engineers from JINR in the CMS experiment at the CERN LHC. In particular, it covers the contributions to activities related to the detector maintenance and operation and to the physics analysis, in the period 2009-2018, to the detector consolidation and upgrade, during the first LHC long shutdown in 2013-2015 (LS1), and to the R&D and the construction for the Phase I upgrades, during the second LHC long shutdown in 2019-2020 (LS2). It also includes an overview of the R&D activities that are being carried out in view of the phase II upgrades (2023-2026), while the plans for the participation in the construction activities for the phase II upgrades are not yet defined.

The JINR CMS group has given very important contributions to the construction, maintenance, operation and upgrades of the endcap inner detectors. In particular, it has the full responsibility for the Endcap Hadron Calorimeters (HE) and the First Forward Muon Station (ME1/1). This responsibility entailed the maintenance and operation of the detector, during the data taking periods 2009-2012 (Run1) and 2015-2018 (Run2), and the detector consolidation and upgrade activities carried out during LS1. The performance of the HE detector and ME1/1 station met the design specifications and their efficiency (detector active fraction) was very high (97% and 98.5% respectively) throughout Run1 and Run2.

In addition, the JINR CMS group has also contributed to tasks of general interest (service work), as for example the participation in the shift crew for the central operation of the experiment during Run1 and Run2. The contribution of JINR to the CMS computing is also very important, with the successful development and operation of a Tier-2 center based on heterogenous hardware resources (CPUs and GPUs), which is very strategical in view of the challenging requirements set by the high-luminosity LHC upgrade.

Owing to the excellent performance of the CMS detectors and the outstanding performance of the LHC, the CMS collaboration has successfully collected a wealth of data way beyond the original plans, despite of unprecedented challenges set by the extreme conditions in terms of pile-up, particle rates and radiation load. This allowed the CMS collaboration to produce a plethora of data analysis and scientific publications. This success can be certainly ascribed also to the high-quality work of the JINR CMS group.

The JINR CMS group is presently working on the detector upgrades to be installed during the second LHC long shutdown. These upgrades are essential to cope with the increase of the LHC luminosity and preserve the same level of performance as that of Run1 and Run2. These upgrades deal with the replacement of the readout electronics and the low-voltage distribution boards of all inner muon stations, and the replacement of hybrid photodetectors (HPDs) with silicon photomultipliers (SiPMTs) in the endcap hadron calorimeters. The status of these upgrade activities is well detailed in the report, including results on the characterization of prototypes and series tests, and it is well on track to be completed by 2020.

Concerning the scientific production, it is reported that the JINR CMS group has contributed so far to the analysis and editorial work of eight papers published by CMS in scientific journals, which corresponds to an average of one paper a year. The number of publications is low compared to the scope of the participation of JINR in the CMS experiment and the overall contributed resources. Therefore, the referee strongly encourages the JINR CMS group to make all possible efforts to create the conditions to attract more PhD students and young PhD holders aiming at a substantial increase of its scientific production.

Concerning the Phase II upgrades, the referee strongly recommends the JINR CMS collaboration to elaborate a plan for its contributions in agreement with the CMS Management, including a resource plan for the overall participation of JINR in the CMS experiment in the period 2020-2026. Such a plan should also include a clear definition of the resources and tasks allocated to individual laboratories.

In conclusion, the referee proposes to approve the funds requested for the commissioning of the HE and ME1/1 detectors in 2020, their maintenance and operation in the period 2021-2023 (Run3), the participation in the CMS central operation and data taking activities in Run3, and the participation in the data processing and physics analysis. The referee judges the requested funds proportionate to the scope of the activities, which also include institutional obligations, as the participation in activities of common interest ("service work"), shifts for the data taking and payment of the M&O-A fees.

Finally, the referee recommends the JINR CMS group to increase its efforts on the physics data analysis and preparation of scientific publications.

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