



Letter about Peking University Group's Contribution in CMS-GEM Upgrade Project

Peking University group is actively engaged in CMS-GEM Phase II upgrade project in last five years. They have made the following main contributions:

- PKU group engaged in prototyping the GE1/1 GEB (GEM Electronics Board) and was responsible for the mass production and the Quality Control (QC) of all GE1/1 GEBs (totally 288 + spare boards) in China. The GEBs were all produced and tested in China then shipped to CERN where they have been assembled on GE1/1 GEM detectors. GE1/1 has been installed in CMS in 2020.
- PKU group is responsible for the design, the prototyping, the mass-production and the QC of 8 types of GE2/1 GEBs (called M1-M8). The test of the GE2/1 GEB prototypes showed excellent performances meeting all the CMS requirements. The mass-production of GE2/1 GEBs (totally 288 + spare boards) is expected to start in Sept. 2021.
- PKU group is responsible for the prototyping, the mass-production and the QC of GE2/1 GEM external frames (M1-M8). The mass-production of all GEM FR4 external frames (totally 288 + spare frames) was completed, the frames were shipped to CERN. All meet the CMS requirements and were qualified to be used for the upcoming assembly of the CMS GE2/1 detectors.
- Peking University's GEM laboratory has also established all necessary hardware and software platforms which are obligatory for GEM assembly and test according to CMS-GEM standards. The PKU group has tested and validated all QC processes with a small size GEM prototype and a full size GE1/1 GEM detector. Peking University is now one of the official CMS-GEM production sites. PKU group is expected to produce GE2/1 M5 GEMs (totally 36 + spare chambers) starting from Sept. 2021.

It should be noted that, due to the Covid-19 situation, the CMS-GEM chamber mass production plan is delayed by approximately one year, thus it is not feasible to provide test results of PKU-produced GEM chamber at the moment. We confirm that the GEM chambers assembled and QC qualified following CMS-GEM standard procedure will be acknowledged as satisfying criteria specified in CMS-GEM TDR document.

All the contributions from the PKU group to the CMS-GEM Phase II project have been crucial. The PKU members have always demonstrated the highest level of commitment to the CMS-GEM project, always taking care of challenging duties (complex designs, mass production, quality control, working group convenorship, etc.). The Peking University has always been a very strong partner of the CMS-GEM project and is very much appreciated by the whole CMS Collaboration. In conclusion, the CMS-GEM project management strongly recommend the continuation of the support from Ministry of Science and Technology of China to Peking University for the CMS-GEM upgrade project.

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Date: 18 Aug. 2021