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## Construction and Commissioning of the CMS Phase 1 Pixel Detector

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The original CMS pixel detector was built out of pixel detectors arranged in three barrel layers (BPIX) and two forward disks in each endcap (FPIX). It was designed for the nominal instantaneous LHC luminosity of  $1 \times 10^{34} \text{ cm}^{-2} \text{ s}^{-1}$ . Under the conditions expected in the coming years, which will see an increase of a factor two of the instantaneous luminosity, the CMS pixel detector will see a dynamic inefficiency caused by data losses due to buffer overflows. For this reason the CMS Collaboration has installed, during the recent extended end of year shutdown, a replacement pixel detector.

The Phase I upgrade of the CMS pixel detector will operate at full efficiency at an instantaneous luminosity of  $2 \times 10^{34} \text{ cm}^{-2} \text{ s}^{-1}$  with increased detector acceptance and additional redundancy for the tracking. Both barrel and endcap disk system now feature one extra layer (4 barrel layers and 3 endcap disks), and a digital readout that provides a large enough bandwidth to read out its 124M pixel channels (87.7% more pixels compared to the previous system). The detector is now also fitted with a bi-phase CO<sub>2</sub> cooling system that reduces the material budget in the tracking region. The detector has been installed inside the CMS tracker at the start of 2017 and is now taking data.

This contribution will review the construction of the Phase I detector with a focus on the challenges and difficulties encountered, as well as the lessons learned for future upgrades. It will focus on the detector construction, installation, and support services. It will also discuss the early experiences in the commissioning and operation of the CMS phase-I pixel detector prior to the availability of colliding beams.

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