THE UPGRADE OF THE CMS PIXEL DETECTOR FOR LHC PHASE 1

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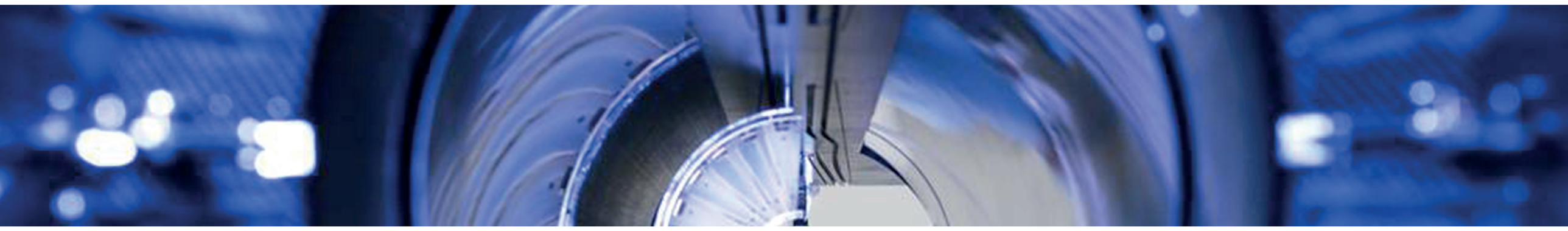
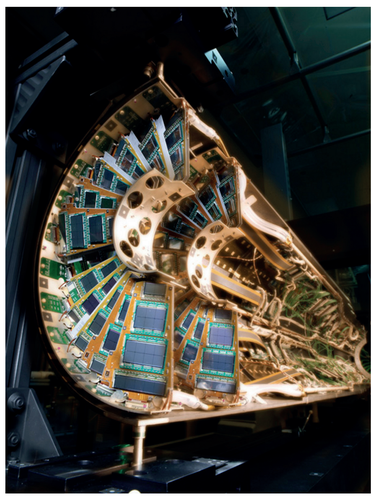


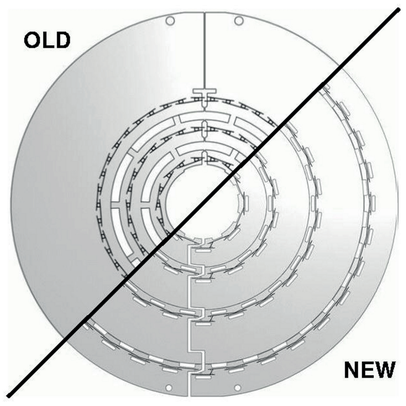
After a little over one year of operation, the LHC is operating smoothly and delivering luminosities up to 10^{33} $cm^{-2}s^{-1}$, while the CMS detector is performing very well collecting over 380 pb^{-1} of data. However, datataking will continue for many years to come, and one of the main goals for the coming years is to reach and pass the design luminosity of 10^{34} $cm^{-2}s^{-1}$.
As the accelerator reaches new frontiers, CMS needs to operate reliably in the new environment: this means improved radiation hardness and better handling of large occupancy events resulting from high pileup. This calls for an upgrade of the CMS experiment, including a new pixel detector. Along with these improvements, the new design will study better and newer solutions to reduce the amount of material in the inner part of the detector and improve its electronics and cooling. To accomplish all of these tasks a new Pixel Detector has been designed with lighter supports, CO_2 cooling system and a full 4hits per track coverage up to pseudorapidities of 2.5.

CURRENT DESIGN

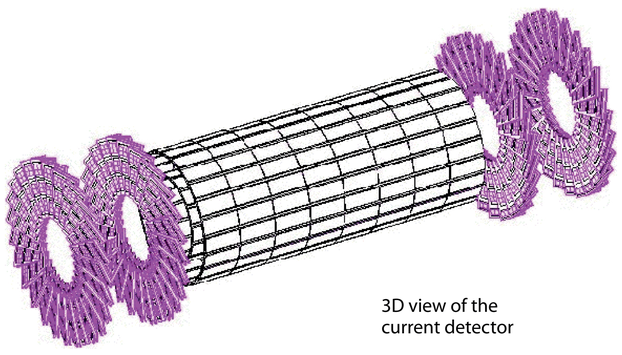
The current CMS tracker features an inner Pixel Detector and an outer Strip detector. Only the Pixel detector will be replaced in the Phase 1 upgrade. The current Pixel Detector consists of a central barrel divided into 3 layers and two endcaps divided into two disks, giving 3 good hits per track coverage, and making it a good device for tracking and bjet tagging purposes.



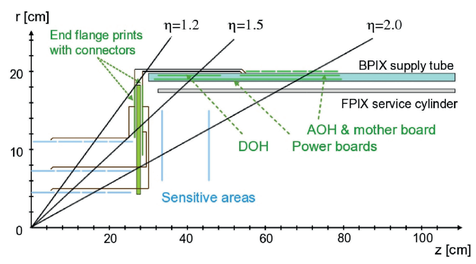
Picture of the current forward pixel detector.



Comparison of the old and new barrel layers. Also a new inner layers with smaller radius in combination with a new beam pipe has been designed.



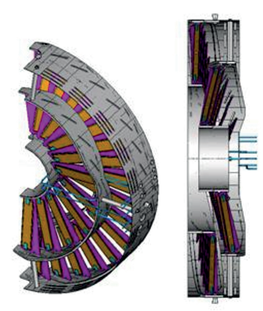
3D view of the current detector



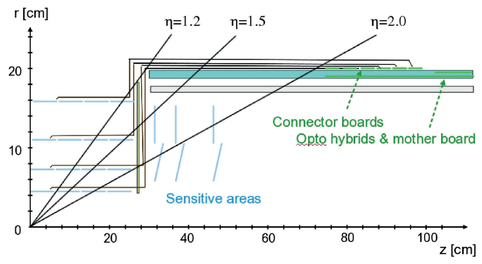
Graphical view of the services and their location in the current tracker

PHASE1 DESIGN

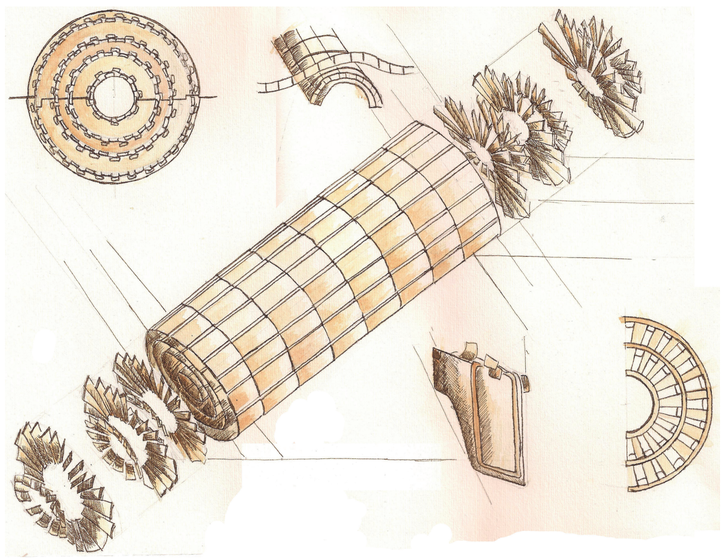
The new Pixel Detector will increase the number of hits per track in order to provide better tracking and bjet tagging performance in the high pileup scenario that CMS will face in the future. For this reason an extra barrel layer and an extra disk per side have been added to the current design. Moreover, new supports and cooling have been studied in order to reduce the amount of Material. Since the Pixel Detector is closest to the interaction point, this not only improves the performance of the Pixel Detector itself, but also the tracking and hence the whole CMS experiment.



View of the new disk design for the end-cap. Now the blades are all identical and divided into inner (rotated to enhance charge sharing) and outer rings.

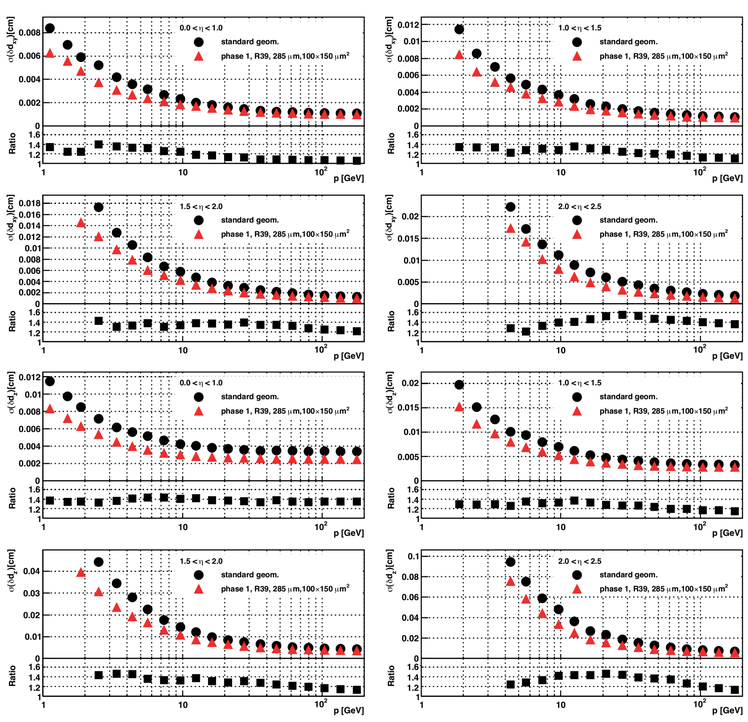


Graphical view of the services and their location in the new tracker.

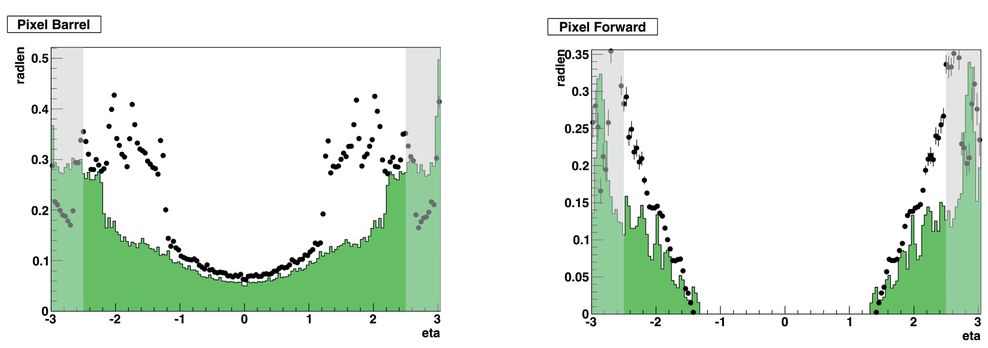


Artistic view of the new pixel detector

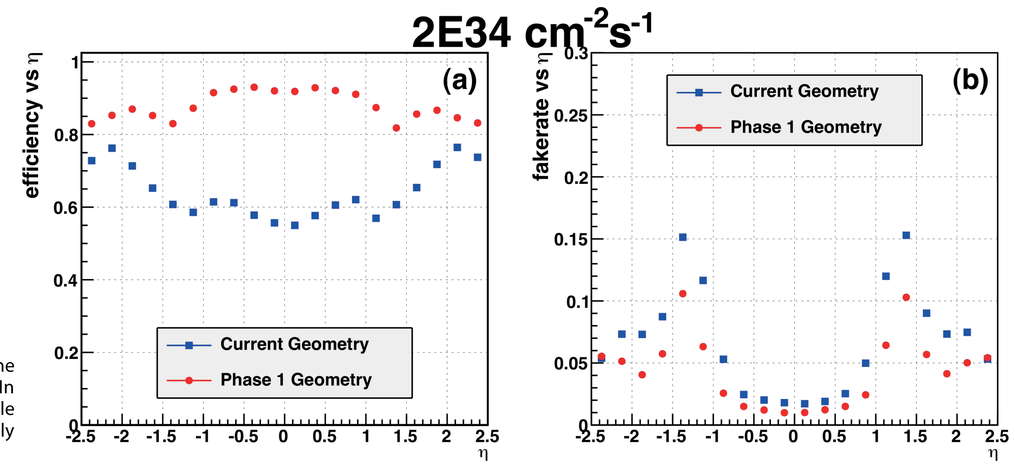
SIMULATION RESULTS



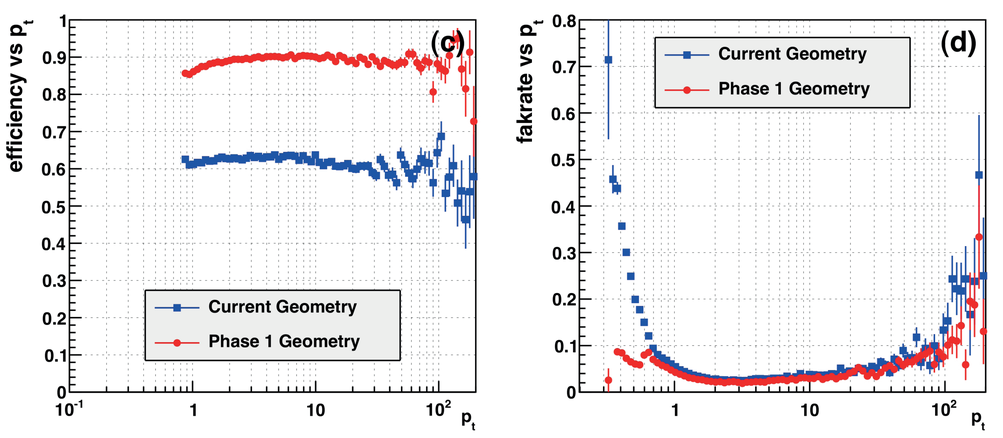
Impact parameter resolution for current (black) and proposed (red) geometry, top transverse and bottom longitudinal IP. Also the ratio is shown at the bottom of each plot of each region in eta.



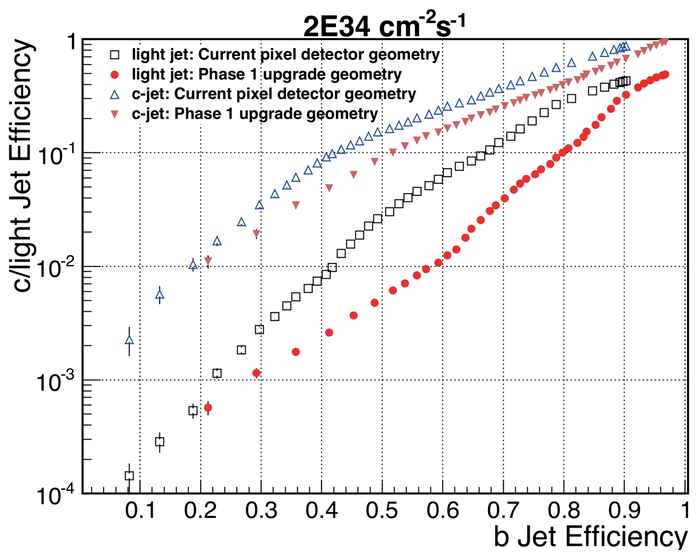
Material budget in radiation lengths for the current (black) and proposed (green) pixel detector.
Barrel section on the left and forward section on the right.



Tracking efficiency vs eta (top) and pt (bottom) for the current geometry (blue) and the phase1 proposed geometry (red).



At high pileup the performance is affected by data loss which is due to the readout and is simulated for both the current and upgrade geometries. In addition modifications to the regular seeding and tracking algorithms to tackle the fake rate present at high pileup are used, though they have not been fully optimized.



b-tagging performance in the high pileup scenario (50 events per crossing), efficiency for light jets (uds quarks and gluons) vs b-jets efficiency.