The Tracker Endcap Pixel detector for CMS phase II upgrade

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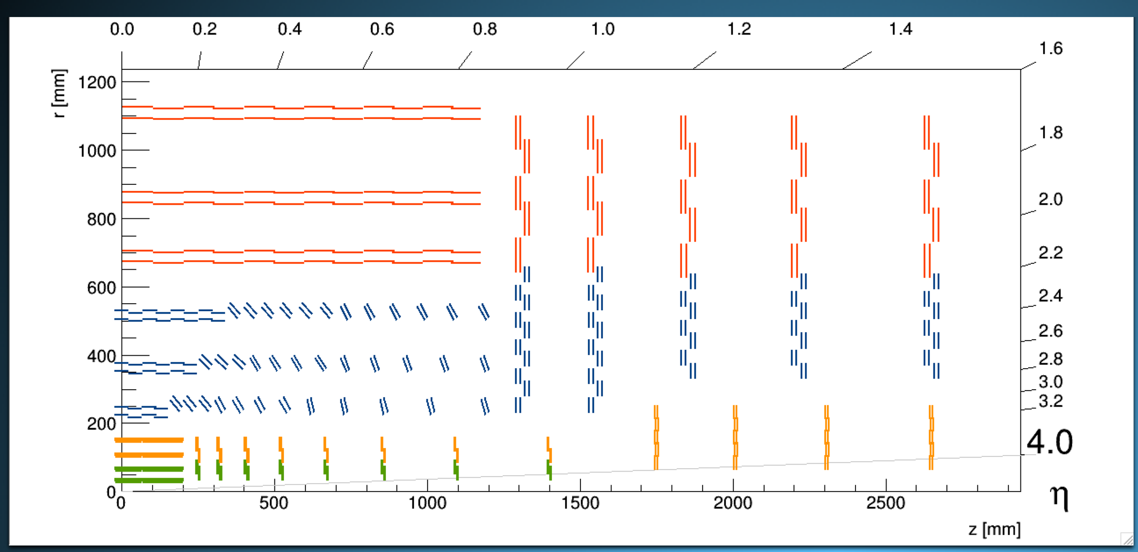
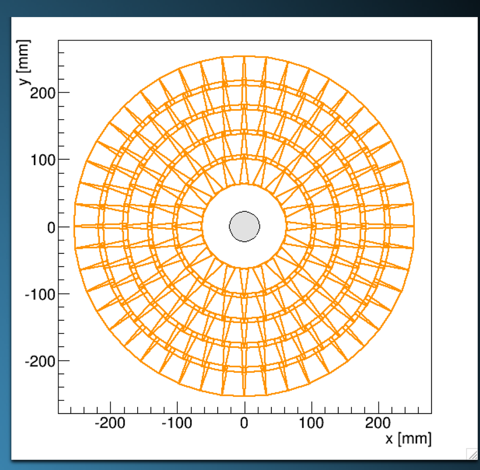
ABSTRACT: After the high-luminosity upgrade of the LHC (HL-LHC), the instantaneous luminosity will increase to unprecedented values of 5-7x10^{34}cm^{-2}s^{-1}. In order to cope with these conditions the whole CMS silicon tracker detector will be replaced. This presentation describes the upgrade of the inner pixel system. The new inner pixel detector will be composed of three sub-detectors: the barrel detector (TBPX) consisting of four concentric cylindrical layers, the forward detector (TFPX) consisting of eight small disks on each side, and the endcap detector (TEPX) with four large disks on each side. Each of these systems will cover a different region in pseudorapidity, with TEPX extending the coverage up to |η|<4.0. The upgraded detector will feature a new readout chip and sensor design, with a pixel area six times smaller than the present one. Furthermore, the services will be redesigned for the new system. In this contribution the new TEPX detector will be presented, with particular focus on the new layout, services, and physic performance of the system.

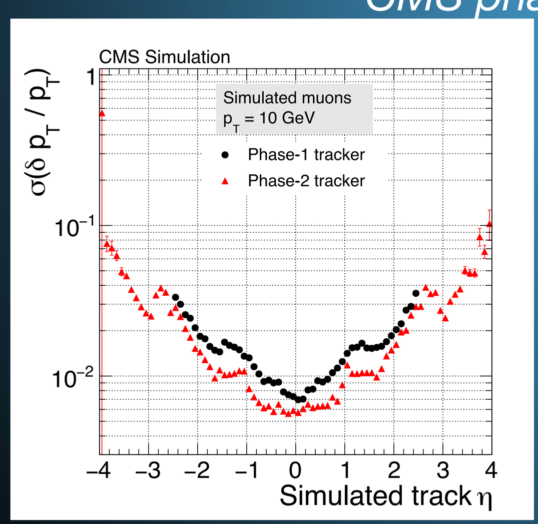
Phase II tracker layout



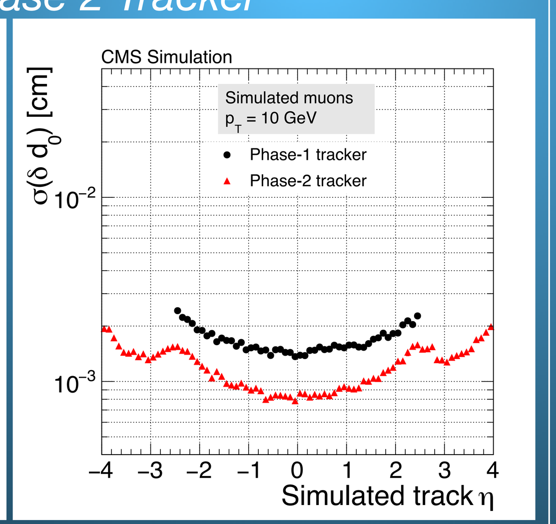
CMS phase 2 Tracker



TEPX Disk



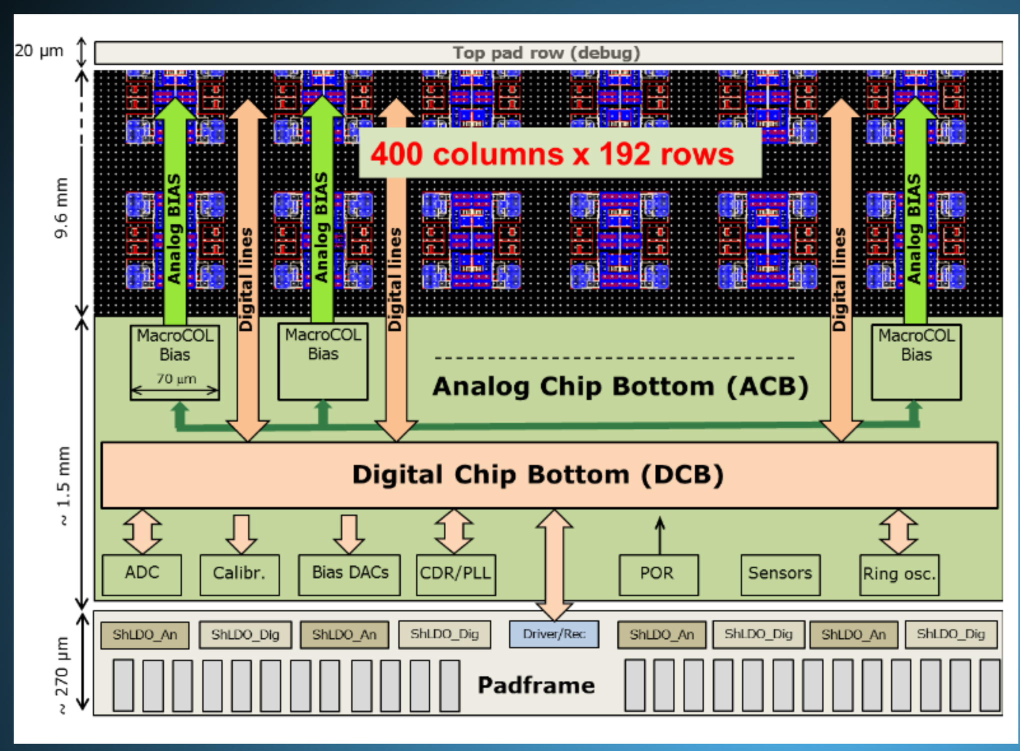
$\sigma(\delta p_T/p_T)$ vs η



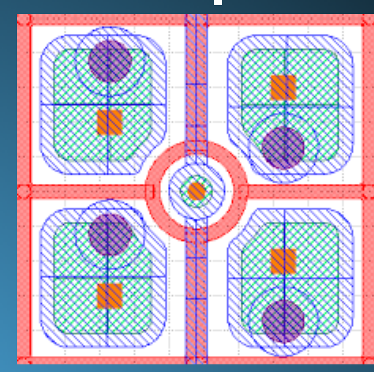
$\sigma(\delta d_0)$ vs η

The TEPX will extend the coverage up to |η|<4.0. Forward physics will benefit from this, in particular B physics and processes with VBF jets. Furthermore the most internal ring of the last disks will be used to measure the luminosity online.

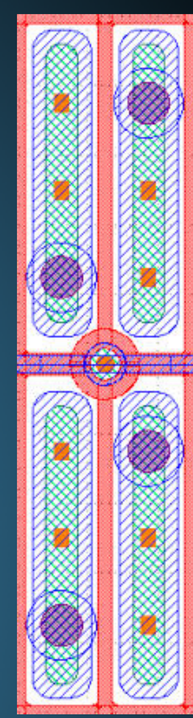
Pixel sensor and readout chip



RD53A Functional Floorplan



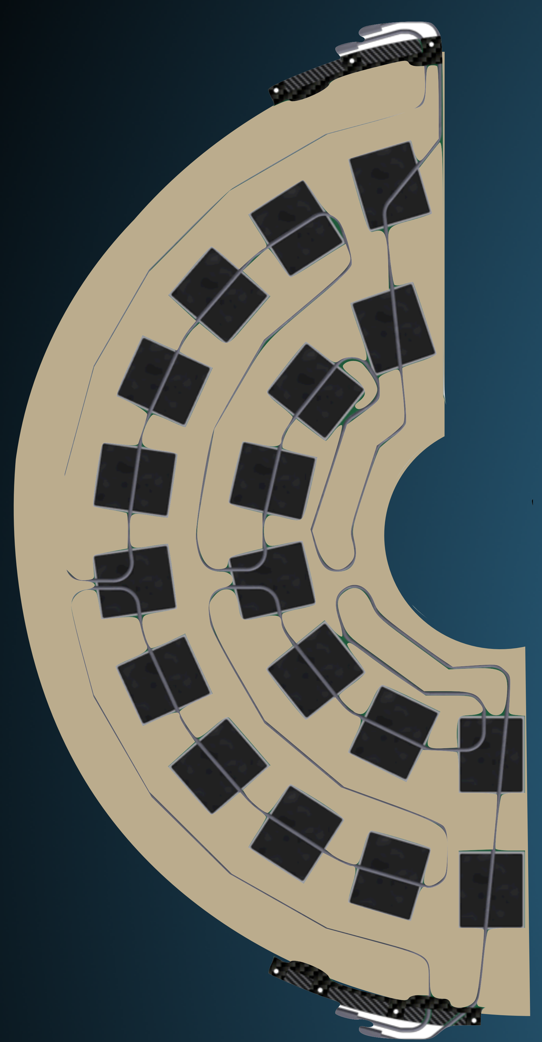
50x50 μm²



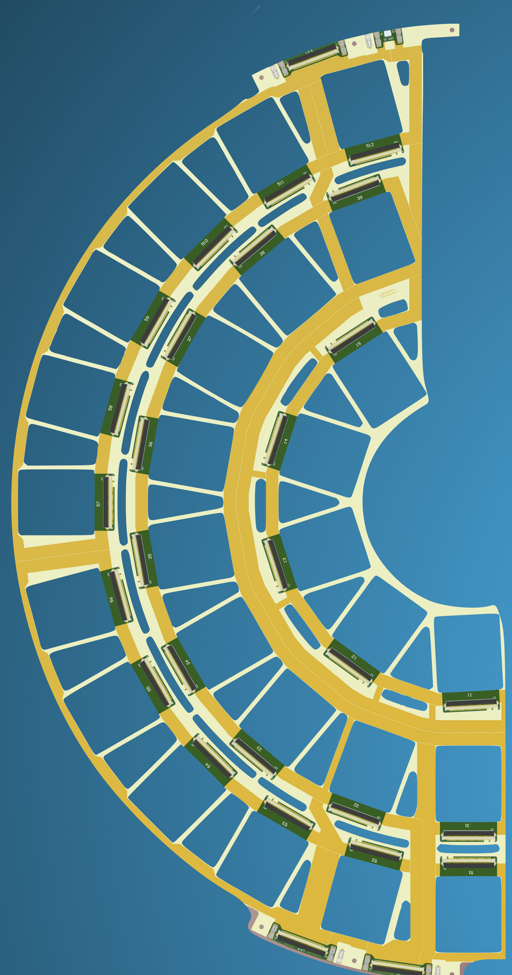
100x25 μm²

The pixel detector modules are built from planar silicon sensors with a thickness of 150 μm bump-bonded to RD53 readout chips (ROCs). In TEPX, a module consists of four ROCs. Two pixel sizes are under study: 50x50 μm² or 100x25 μm². A High Density Interconnection (HDI) is glued on top of the module. The maximum foreseen hit-rate is 360 MHz/cm² for the innermost ring of TEPX.

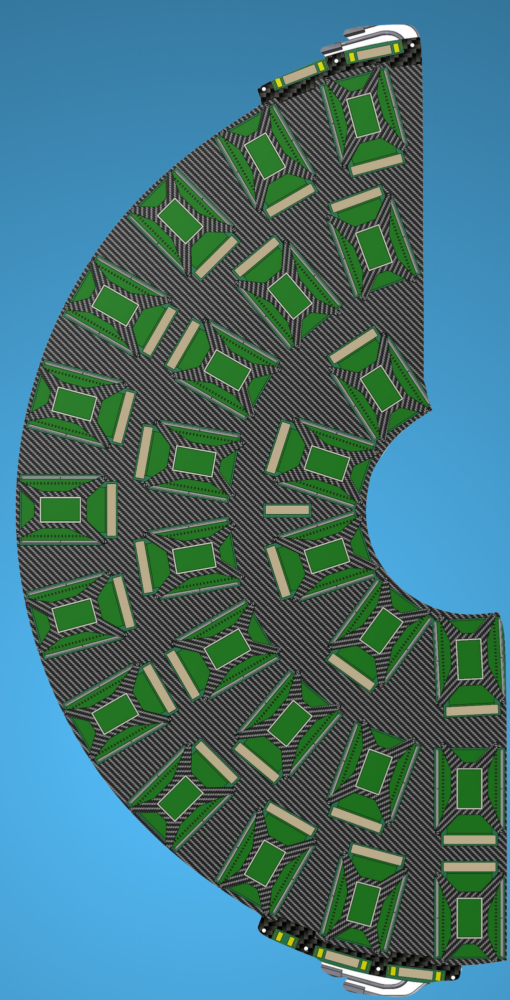
Disk structure



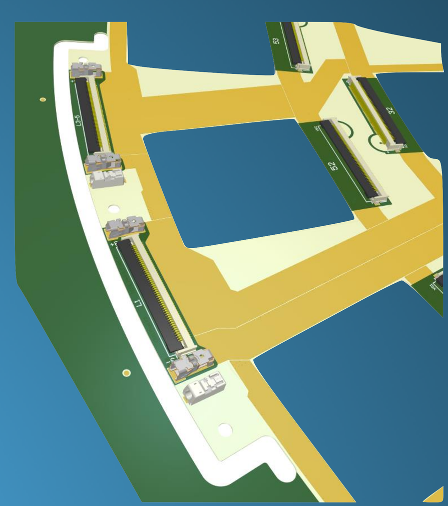
Airex core with graphite/TPG heat sinks and two cooling loops.



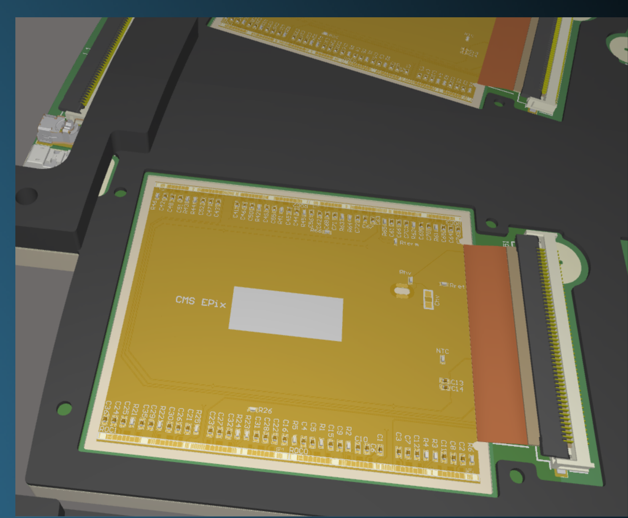
PCB Layer



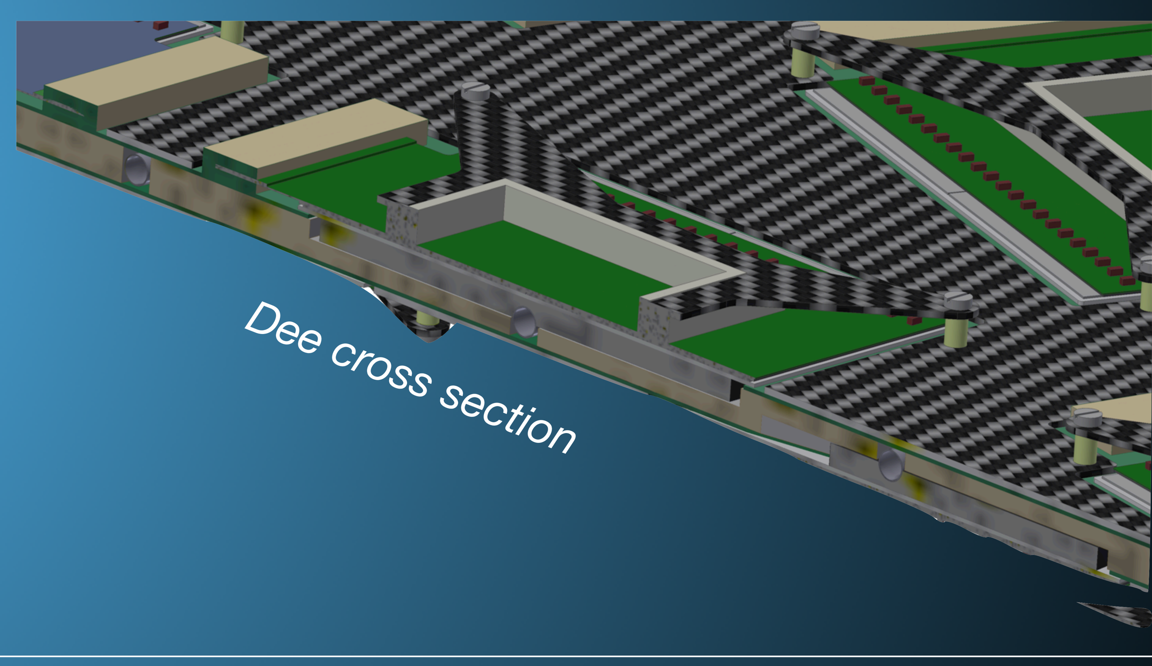
CFK stiffener on top of the sandwich structure.



Connector on PCB



HDI

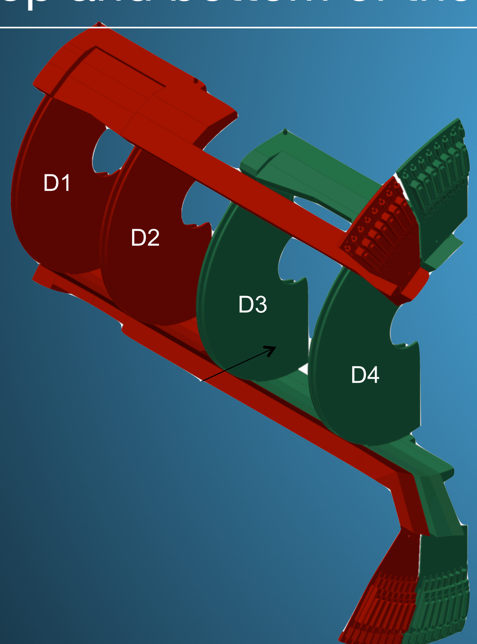


Dee cross section

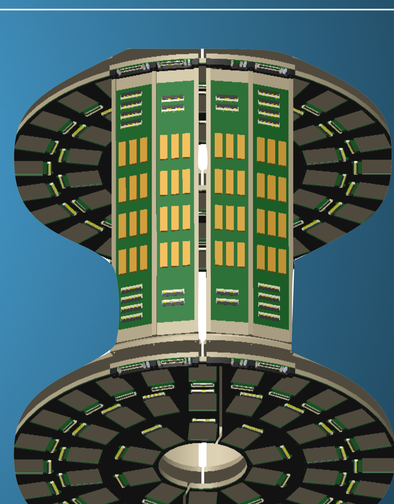
Each disk is split in two halves (Double-Dee). Each Dee will feature a sandwich structure with a total of five layers. The core is an Airex layer for mechanical stability which will carry the single cooling loops and the heat sinks. On each side of the core a PCB layer 400 μm thick will connect the modules to the readout electronic and power. This solution allows to have one connector per module and avoid using cables. The last layer will be a stiffening carbon layer, on top of it X-shaped carbon fibre holders will keep the modules in position. Each Dee will host 44 modules for a total of 1408 for the full TEPX detector. Connectors at the top and bottom of each Dee will connect signal, power and HV.

TEPX mechanical design

Four Double-Dees will be arranged in a quadrant. The incoming and outgoing signal from and to the modules will be converted from electrical to optical signal using Low Power GigaBit Transceiver (lpGBT) with a bandwidth of 10 Gb/s. They will be hosted on the top and the bottom of the quadrant. Each Double-Dee uses 24 lpGBT, for a total of 384 for all the TEPX detector. The lpGBTs will be placed at the top and bottom of the quadrant.



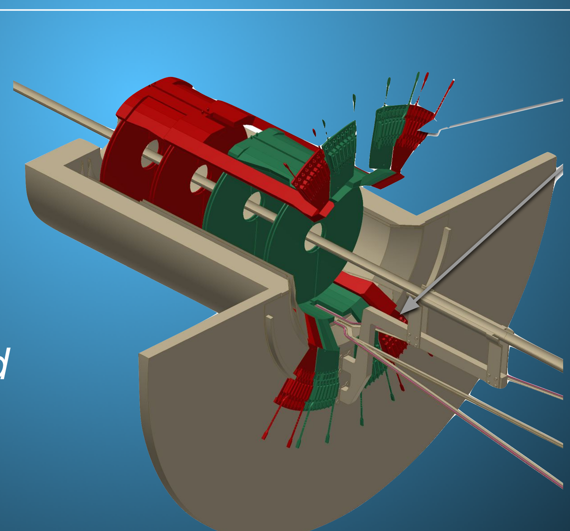
TEPX quadrant. The two halves are independent because of space constraint during the installation.



Readout electronics arrangement at the top (bottom) of the half quadrant.

Status and future plan

- Design of TEPX moving towards prototyping phase
- TEPX will be installed in CMS during LS3 to improve the tracking capability of CMS at HL-LHC by extending the acceptance to |η|<4



Two quadrants installed at Point 5

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