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CMS-Phase2 Upgrade of the Inner Tracker: TBPX service flanges

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For the HL-LHC the CMS detector requires a major upgrade, called Phase-2 Upgrade, in order to provide the necessary physics performance under the challenging conditions of high luminosity. The CMS Tracker will be entirely replaced with a new tracking system, with a substantial increase in the number of channels and an improved spatial resolution. The Tracker Barrel Pixel detector (TBPX) is the central innermost part of the Inner Tracker (IT), and it is made out of four cylindrical layers, each 400 mm long, located between 30 mm and 146.5 mm away from the beamline. The layers are composed of ladders, structural elements in carbon fiber, on which the silicon modules are positioned, supported by mechanical flanges. The flanges, allocated at the entrance of the barrel, play an essential role for the module supports position and for the services distribution.

The mechanical flanges allow for assembly of the four cylindrical layers with precise positioning of each ladder, the structural support of the modules. We have investigated different materials for the production of the mechanical flanges, evaluating standard PEEK, carbon PEEK and other innovative composite materials. Many efforts are being employed for the complex design, the feasibility study and the manufacturing process.

The flanges also support the distribution of CCA (Copper Clad Aluminum) power cables, CO2 cooling tubes, and e-links (twisted pair cables sending I/O signal to the LPGBT). A Flexible Printed Circuit (FPC) with aluminum traces has been designed to route serial powering and sensor high voltage lines to the detector modules, solving numerous problems of minimum space, bending radius and material quantity. Much effort has been spent in the design of these circuits, in compliance with the specifications in terms of power, thermal dissipation, radiation resistance and material budget. We evaluated different designs, manufacturing technologies and stratigraphies in order to obtain a circuit which respects the specifications. We are working in strong collaboration with other research institutes, several companies and CERN workshop.

The mechanical flange design allows the correct fixing of the stainless still mini-tubes, used for the module CO2 cooling, with dedicated clamps that guarantee the correct tube position during the flanges assembly procedure and provide FPC heat dissipation. The e-link routing has dedicated portions on the flange to allow easy replacement of L1-layer planned after three years of running. Due to the numerous services to be arranged in dedicated paths and compatible with the assembly procedure, specific devices have been implemented in the structure.

3D printing has proved to be an excellent solution to validate the preliminary design phase of prototypes and in the realization of jigs and tools for the numerous assembly steps. Low production cost and high production speed allowed the printing of several jigs, gluing templates, handling/assembly tools, bending masks and various mockups for the construction and the validation of the first prototypes.

Author: GARRAFA BOTTA, Simone (Universita e INFN Torino (IT))

Co-authors: BENVENUTI, Daniele (Universita & INFN Pisa (IT)); BIANCHI, Francesco (Universita e INFN, Perugia (IT)); DEMARIA, Lino (Universita e INFN Torino (IT)); COLI, Silvia (Universita e INFN Torino (IT))

Presenter: GARRAFA BOTTA, Simone (Universita e INFN Torino (IT))

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