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Design and First Experience of the Prototype Pixel Layers for the ALICE FoCal

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University of Bergen is involved in developing two calorimeters: (1) the pixel section of the Electromagnetic Forward Calorimeter (FoCal-E) for the ALICE Upgrade and (2) the Digital Tracking Calorimeter (DTC) for the proton Computed Tomography (pCT) prototype. Both designs utilize the ALPIDE sensors which are connected to aluminum-polyimide flexible cables applying Single-point Tape Automated Bonding (SpTAB). This contribution describes the development of the first multi-chip string prototypes, their performance, and the characterization of the high-speed links of the front-end electronics and towards the readout. Moreover, we present the experience with the prototypes both in the laboratory and test beam setups.

Summary (500 words)

Both FoCal-E and pCT will arrange the ALPIDE sensors in so-called strings. A string consists of several ALPIDE sensors, a chip cable, and a flex cable. The cables are assembled using adhesiveless polyimide-aluminum flexible cables. Each individual sensor is SpTABed (otherwise known as ultrasonic welded) to a shorter single-layer flex (called chip cable). Multiple of these are then bonded to a longer double-layer flex cable, see Figure 1. This flex cable has a stiffener at the end to ease the insertion of the string in a ZIF connector. Furthermore, passive SMD components such as termination resistors and capacitors are soldered on the aluminum traces of the flex cable. For improved handling, groups of strings are glued side by side on a metal carrier.

To ensure one large active area, two carriers can be positioned either face-to-face (as in pCT) or back-to-back (as in FoCal-E). The constraint in both cases is the mechanical design of individual calorimeters. Also, in regard to the absorber material and thickness between the layers. As of now, there are two different segmentation of the string design:

9-chip string for the pCT offering an active area of 15 mm x 270 mm and total dimensions of 27 mm x 310 mm.
15-chip string for the FoCal-E offering an active area of 15 mm x 450 mm and total dimensions of 27 mm x 490 mm.
The string design ensures the typical impedance of 100 Ω complying with the LVDS lines for ALPIDE sensor. This is important in particular for the 1.2 Gbps data links of the ALPIDE and the total bandwidth of the string. Considering that the ALPIDE sensor requires a recommended operational voltage of about 1.8 V, the string design must also guarantee low voltage drop. This is especially true for the longer 15-chip string. Several prototypes of the 9-chip string have been successfully produced and verified. The first 15-chip string prototype is expected to be produced and tested in 2023. The string development doesn't only take into account the electrical and mechanical quality of the string but the optimization of the production too.

We will present the design approach that ensures good signal and power integrity between the front-end and the off-detector electronics (readout). We will also show the simulations and measurements that verify the design. In addition, a possible solution will be presented on how to connect the string via an intermediate PCB to the readout and power. Finally, we will outline the experience with the SpTAB interconnection technique and the flexible cables.

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