An ultra-low material budget Cu-based flexible cable for the CBM-MVD *

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The CBM Micro-Vertex Detector (MVD) relies on employing a material budget x/X_0 per detector station of 0.3% (first station) to 0.5% (following stations) to allow for a secondary vertex resolution of better than 70 μm with typical pixel pitches of about 20 $\mu\mathrm{m}$. To reach this ambitious goal, all components in the acceptance of the detector have to be challenged w.r.t. their impact on the material budget, while at the same time maintaining their cutting-edge performance regarding mechanical and electrical properties as well as radiation hardness. In addtion, the sensor readout has to be robust with low noise occupancy, which puts strong constraints on the electrical properties of the rather long cables connecting the sensors with the front-end electronics (FEE) being outside the acceptance of the detector. Especially in the outer stations, substantial parts of those cables are placed inside the acceptance and hence contribute to multiple scattering. Those cables are flexible printed circuits (FPC) and provide power to the CMOS Pixel Sensors (CPS), allow to control them, and to read out the hits. The previous-generation cable was not specifically optimized for ultra-low material budget, being a copper-based cable with a layer thickness of about 25 $\mu\mathrm{m}$. It was successfully tested in a beamtime with the CBM-MVD prototype [1].

Reducing the dominant factor of the material budget meant reducing the thickness of the copper layer, see Tab. 1. The cable was redesigned with a readout to the side (see Fig. 1), a smaller feature size (80 μm) and thus a reduced total cable width, and copper traces with a thickness of only 12 $\mu\mathrm{m}$. The cables were manufactured using a commercial technology offered by ILFA [2].

Table 1: Material budget of the new cable.

Layer	d [μm]	x/X_0	Si-equiv [μm]
Coverlay	26	0.009 %	8.6
Copper	$40\% \cdot 12$	0.033 %	31.3
Polyimide	25	0.009 %	8.2
Sum	63	0.051 %	48.1

Some problems may arise from the ultra-thin layout though: Without an accompanying ground layer, the traces will not have an excellently controlled impedance. In addition, the resistance of the power supply lines becomes substantial. To compensate for this, their width was increased to 360 $\mu\mathrm{m}$ resulting in visible areas of higher material budget in Fig. 1. Dedicated tests with a new sensor test stand will evaluate the effect of the missing shielding and possible impedance mismatch of signal lines as well as the higher resistance of the power supply lines. This test stand comprises a compact, Peltier-based temperature control unit, and a readout chain using a special test mode of the sensor which makes it possible to measure transfer functions. This allows to deduce the temporal and fixed pattern noise of a reference sensor to conduct extensive systematic tests of flex cable generations.

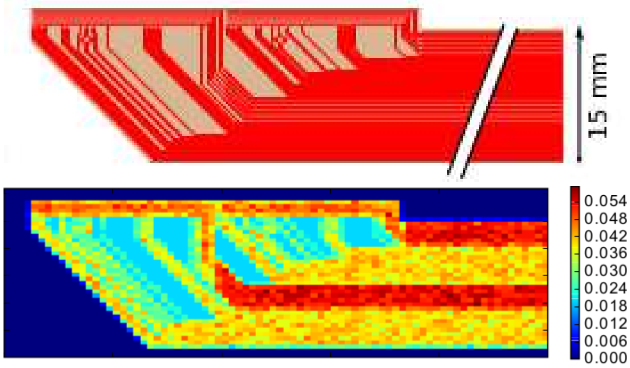

Figure 1: CAD layout of the new ultra-thin FPC showing the bonding zone and the part of the cable situated in the acceptance of the detector (top); an analysis of its material budget in % of x/X_0 (bottom).

Another possible approach to reach an even smaller material budget employs Aluminium instead of Copper for the conductive layer. Aluminium has a smaller conductivity (3.5010^7 S/m vs. $5.96 \cdot 10^7$ S/m) but at the same time a much larger radiation length (88.97 mm vs. 14.36 mm), suggesting an improvement in the material budget by a factor of 3.6. The downside of this non-standard Aluminium-based technology is the lower production reliablity, and thus higher cost and production times.

To summarize, a new ultra-thin design of the FPC for the CBM Micro-Vertex Detector was created and the cables produced. Its suitability will be analyzed including its electrical performance and integration stability. Further technologies to reduce the material budget even more are being evaluated.

References

[1] M. Koziel *et al.*, Nucl. Instrum. Methods **A 732** (2013) 515

[2] ILFA Industrieelektronik und Leiterplattenfertigung aller Art GmbH, Hannover, Germany

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