Development status of long data cable for sPHENIX-INTT detector

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The intermediate tracker (INTT) is a silicon strip barrel detector for the sPHENIX experiment.[1)] INTT requires a special extension cable for data transfer between the INTT module and readout electronics. The data cable must satisfy the following requirements to fit the tight space available for INTT at the sPHENIX detector: (1) flexibility, (2) a very long length of at least 120 cm, (3) high-density signal lines (128 lines/5 cm width), and (4) high-speed signal transfer (by LVDS).[2)] The development of the cable is the most challenging part of the INTT project.

We performed research and development of the cable in the past two years. The design of the cable was optimized using a signal-transfer simulation with the strip-line structure. We then made a prototype of the cable using a flexible printed circuit board (FPC) with a liquid crystal polymer (LCP) as the substrate. The LCP realizes a small signal loss because of its small dielectric constant. The electrical and mechanical performance of the prototype were tested.[2)] Based on this knowledge, we made a 120-cm-long prototype cable.

We measured the eye diagram to study the transfer performance of the cable. Figure 1 shows the input (left) and output (right) shapes of the eye diagrams. The signal height is 30% attenuated, and the waveform is rounded. This change in waveform is consistent with the expectation from simulation. We found that the eye is clearly open. To quantify the performance, we will measure the bit error rate.

In June 2019, we performed a beam test with a 120 GeV proton beam at the Fermilab Test Beam Facility (FTBF). The performance of the INTT module

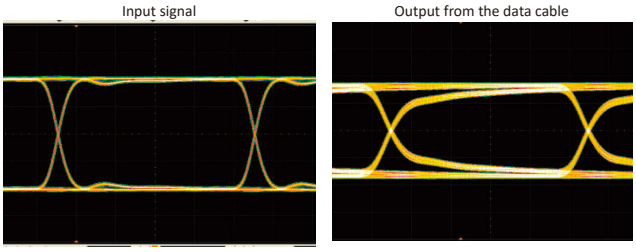

Fig. 1. Eye diagram with (right) and without (left) the cable.

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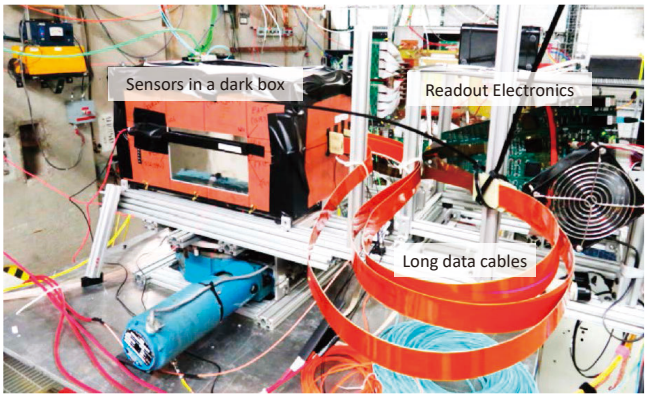

Fig. 2. Setup for testing the cable during the beam test at FTBF.

was evaluated in terms of the detection efficiency and minimum ionizing particle (MIP) peak.[3)] In addition, the prototype cable was tested under a beam environment. The data were taken using the cable together with the INTT module and, later, readout electronics. Figure 2 shows the test setup at the beam test. The INTT modules are installed in a dark box, and the readout electronics are placed. The cable, shown as an orange flat cable that makes loops, is connected to them. This was the first attempt to take data with the full readout chain of the INTT detector. Further investigation is ongoing to quantify the performance under the beam environment.

An issue was found in the production of through holes on the cable. We found that the through holes have nodules caused by the residue of the adhesive sheet used to laminate the FPC layers. Several attempts to clean the through holes by changing the drill process and desmear process were unsuccessful. We will test new adhesive sheets from different manufacturers. These sheets are suitable for LCP according to the catalog.

In summary, the development of an extremely long and high-density cable is in progress. The production version of the cable was made and tested under a beam environment. An issue is under investigation. We will test new adhesive sheets, and a new prototype will be made using a new adhesive sheet and tested during the beam test in May 2020.

References

1) I. Nakagawa *et al.*, in this report.
2) T. Hachiya *et al.*, RIKEN Accel. Prog. Rep. **52**, 128 (2019).
3) A. Suzuki *et al.*, in this report.