

Optical data transmission with over 10 Gbps speed and millimeter profile for detector front-end readout in HEP

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Outline

- **Data rate:** 160, 800 Mbps, 1.6, 5 (LOCId, GBLD), 10 (GBLD10), 14 (VLAD, lpVLAD) and 28 (VLAD+, lpVLAD) Gbps per fiber channel.
- **Optical module:** 15 mm: ST/SC, SFP, VTTx, VTRx, 6 mm: MTx, MTRx, 2 mm: currently being prototyped.
- **Power consumption:** VTTx 100 mW/Gbps, MTx 60 mW/Gbps. Currently prototyped: VLAD 4 mW/Gbps, lpVLAD+ 1.5 mW/Gbps.
- **Serializer ASICs:** GLink (1.25 G), GOL (1.6G), GBTx (4.8G), LOCx2 (2x5.12G), lpGBT (10G), ??? For 14 and 28G?

Data Rate

- LHC current readout: below or around 1 Gbps, with COTS drivers.
- LHC phase-1 upgrade: GBT ASIC family (CERN led) at 4.8 Gbps, LOC ASIC family (SMU) at 5.12 Gbps.
- LHC phase-2 upgrade: lpGBT ASIC family (CERN) 10 Gbps, VLAD ASIC family (SMU) 14 and 28 Gbps.
- For CEPC, we'd propose to use the VLAD based optical modules at 14 or 28 Gbps, especially for the inner trackers.

Optical Module

- LHC current readout: ST, SC and custom made (mostly for trackers).
- LHC phase-1: VTRx (LC based) 14 mm front-panel, and MTx (LC based) 6 mm mid-board.
- LHC phase-2: VL+ module, said to be 2 mm in height, no candidate yet (CERN), a prototype in early 2017 (SMU, CCNU), 2 mm in height, 4 channel arrange at data rates of 56 Gbps or 112 Gbps.
- For CEPC, we'd propose to use the 2 mm module from SMU/CCNU for tracker and MTx for calorimeters.

Power consumption

- LHC current readout: about 200 mW/Gbps.
- LHC phase-1: 60 mW/Gbps (SMU) and 100 mW/Gbps (CERN).
- LHC phase-2: 4 mW/Gbps (CERN) and 1.5-2 mW/Gbps (SMU).
- For CEPC, we'd propose to use the ultra low power and high speed transmitters from SMU/CCNU, especially for inner trackers where we have tight material budget.

Serializer ASICs

- LHC current: GLink (COTS) and GOL (CERN)
- LHC phase-1: GBTx (CERN) and LOCx2, LOCx2-130 (SMU, ultra low power dual channel serializers based on GF-130 nm).
- LHC phase-2: lpGBT (CERN).
- SMU/CCNU have plans to develop single and multi-channel serializers at 14 Gbps and 28 Gbps per channel, based on TSMC or GF 65 nm CMOS.
- For CEPC: too early to offer a suggestion.

Summary

- Reviewed optical transmitters in the LHC era.
- We are reaching the state-of-art of 1 mW/Gbps, 28 Gbps/channel and 2 mm height optical modules.
- This opens doors to not only trackers, but also high granularity calorimeters.
- SMU and CCNU collaborate on R&Ds for CEPC detector optical readout.