

# Cryogenic digital data links for the liquid argon time projection chamber



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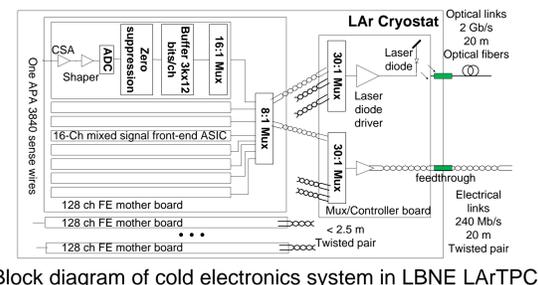
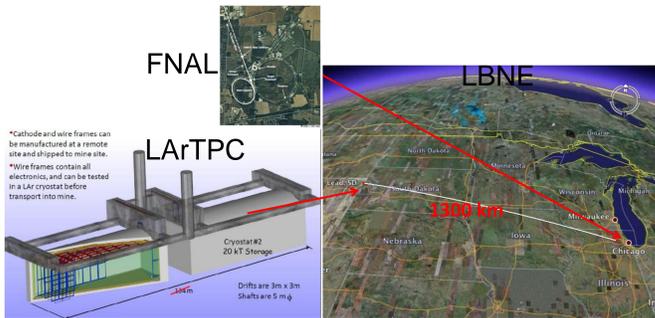
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## Introduction

- Two 20-kton Liquid Argon Time Projection Chamber (LArTPC) modules have been proposed as a potential far-site detector technology of the Long-Baseline Neutrino Experiment (LBNE).
- A cold front-end electronics system has been chosen as the reference design of the LBNE LArTPC for performance, cost, and reliability.
- One of the challenges of the cold front-end electronics is to develop the data links which can reliably operate at liquid argon temperature (about 89 K).
- Two questions we have to address: (1) Can all components of the data links be operated at liquid argon temperature? (2) Are the lifetimes of all components more than the design lifetime (20 years) of the detector? We focus the first question in this poster and will address the second question in the future.



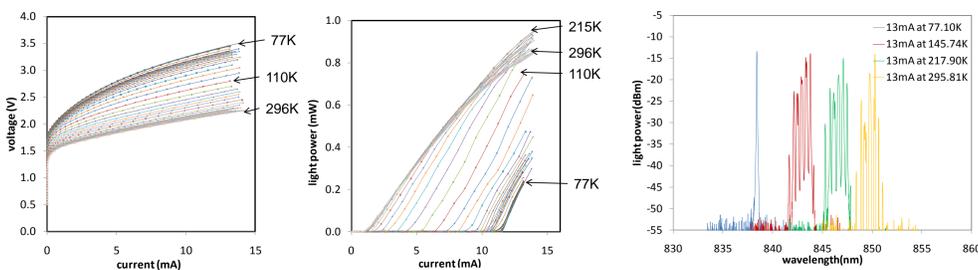
Block diagram of cold electronics system in LBNE LArTPC

## Cryogenic optical links

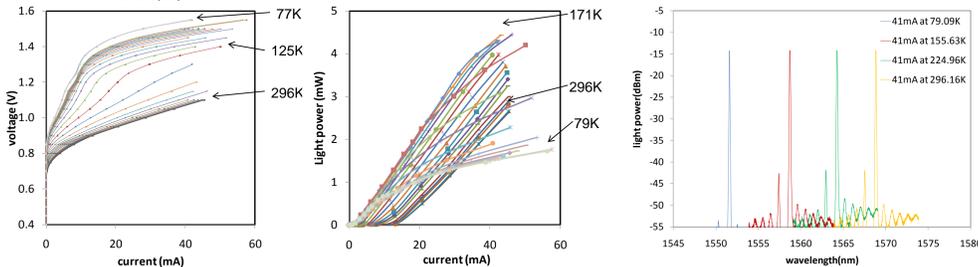
### Laser diodes

All three types of commercial off-the-shelf (COTS) laser diodes continue to function from room temperature to 77 K.

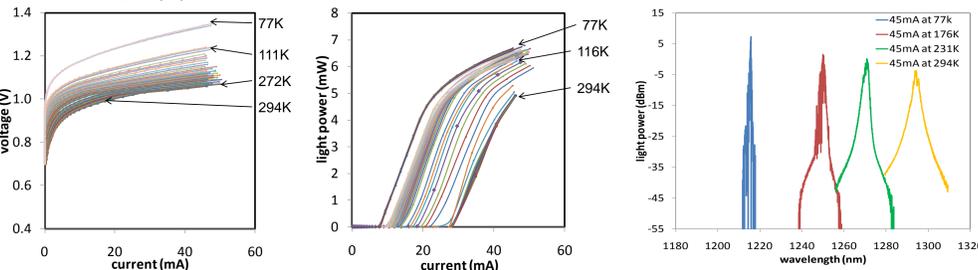
Vertical-cavity surface-emitting laser (VCSEL) 850 nm multimode



Distributed feedback (DFB) laser 1570 nm single mode

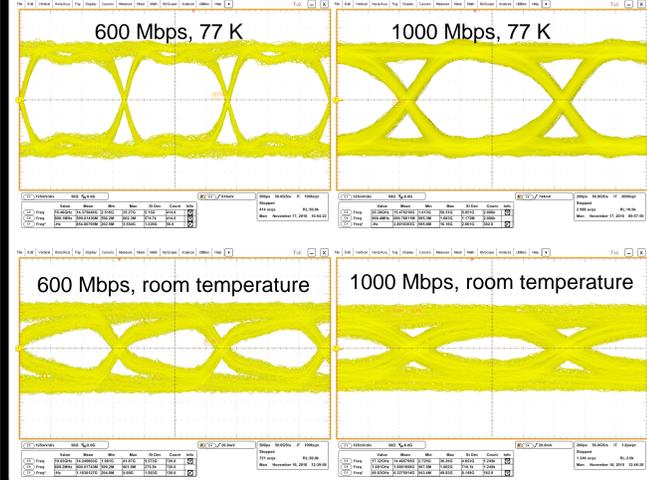


Fabry-Perot (FP) laser 1310 nm single mode



## Cryogenic electrical links

The LVDS driver DS10BR150 from National Semiconductor can driver 20-meter enhanced catalog-5 (CAT5E) twisted pair cables at 77 K up to 1 Gbps.



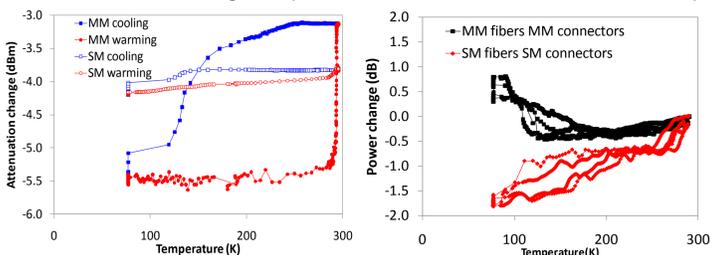
### FPGAs

The FPGA EP2SGX90 in Stratix II GX series, the FPGAs in Cyclone II series, the configuration memory EPCS4, all from Altera, works at 77 K.



## Optical fibers and connectors

The insertion loss change of optical fibers and connectors from room temperature to 77 K is negligible.



Insertion loss change from room temperature to 77K

Change	Multimode	Single mode
Fiber (dB/m)	0.034 ± 0.015	0.005 ± 0.002
Connector (dB)	0.139 ± 0.002	-0.284 ± 0.014

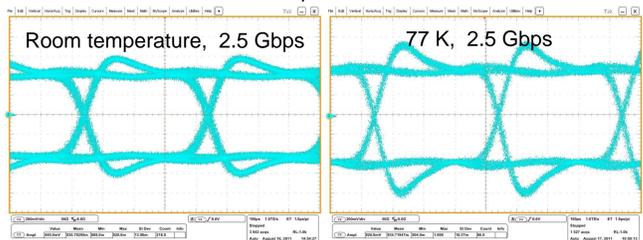
## Resistors and Capacitors

Most resistors and capacitors can be used at 77 K.

	Type	Parameter change (%)
Resistors	Metal Element	-6.59
	Carbon Composition	19.10
	Carbon Film	6.40
	Thin Film	-0.21
	Metal Film	0.08
	Wire wound	0.15
Capacitors	Thick Film	3.48
	Al electrolytic	-100%
	NbO electrolytic	-71% ~ -39%
	Ta Electrolytic	-10%
	C0G/NP0 ceramic	-4.1% ~ 0.35%
	U, X, Y, Z ceramic	-24% ~ 94%
	Film	-13% ~ 3.8%
Mica	-0.35% ~ -0.12%	

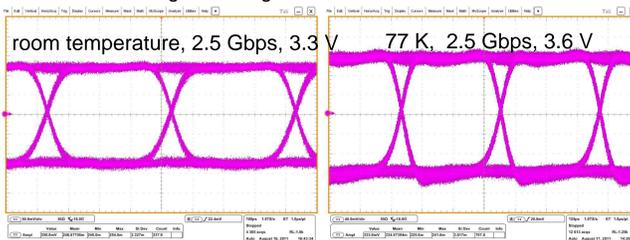
### The serializer

The serializer TLK2501 (from Texas Instruments) functions even better at 77 K than at room temperature



### The laser driver

The laser driver MAX3850 (from Maxim Integrated Products, Inc.) functions at a higher voltage at 77 K.



## Conclusion

We have studied the functionalities of COTS components of cryogenic digital data links for LArTPC. All components continue to work at 77 K except some electrolytic capacitors. Reliability tests will follow. Overall we believe that the cryogenic digital data links are promising.

## Acknowledgments

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## References

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- [3] Mark Christiansen *et al*, R&D towards cryogenic optical links, 2010 JINST 5 C12030.

