DUNE Interface Document: Dual-phase Electronics/DAQ

Definition: This document describes the interface between the DUNE dual-phase far detector Electronics and DAQ. This document describes the necessary interfaces for both DP-Electronics and DAQ to complete the design, fabrication and installation of their subsystems. This document describes the elements of the scope of each subsystem at the interface between them.

Hardware: The hardware interface between DP-Electronics and DAQ has two components:

The first interface are the 10 Gbit/s optical fibers for data transfer between the uTCA crates hosting the digitizer AMC boards of the dual-phase electronics and the network interfaces of the DAQ system. In the baseline design for a DP far detector module it is foreseen to have **x240 10Gbit/s optical fiber links for the charge readout uTCA crates and x5 10Gbit/s optical links for the light readout uTCA crates**. The current fibers specifications is based on multimode OM3 fibers with LC-LC connectors, which are suitable for transmissions up to 300 m distance. On the side of the uTCA crate this optical fiber link will be connected to the optical transceiver in the MCH (providing two SFP+ (XAUI) links). On the DAQ side all these fibers will go to the network interfaces of the LV1 machines of the trigger farm, or to switches, depending on the network topology eventually implemented. The DAQ consortium will purchase the fibers while the DP-Electronics consortium will take care of their installation on the cryostat roof down to the locations of the uTCA crates, which will be located at close distance with respect to the signal feedthrough chimneys. The DP-Electronics consortium will also take care of all the digital electronics in the uTCA crates for both charge and light readout.

The second interface is a single optical fiber link 1Gbit/s syncE, which will go from the White Rabbit Grand Master switch of DUNE to a Master switch of the DP-electronics timing system. The White Rabbit Grand Master will be possibly installed on surface with the GPSDO clock unit which as to be on surface in order to receive the GPS signals. The White Rabbit fiber from the Grand Master allows distributing timing underground for tens of km with sub-ns accuracy, also automatically compensating for the propagation delays. The DP-Electronics consortium will take care of all the other steps concerning the purchase and installation of the White Rabbit switches and slave nodes needed by DP-Electronics system, including the related optical fibers cabling. The common Grand Master provided by the DAQ consortium has the purpose of making sure that the common time base is distributed to all DUNE 10kton Modules. In case it will be needed, the DP-Electronics consortium can also provide this common Grand Master unit and the GPSDO unit. The installation of the fibers going from the common WR Gran Master located on surface to the caverns is supposed to be taken care by LBNF.

It is assumed that the 10 Gbit/s data links will distribute a continuous data streaming to a set of network elements and event building machines which will then define triggers on the basis of the charge and/or light readout information. These triggers will be issued by processing the data over a sliding window, contained in a memory buffer on the trigger farm machines. The depth of this sliding window may tipically go up to 10s, as needed by the Supernova events trigger definition. These triggers will determine if the data contained in the event building buffers are eventually written on disk. Several LV1

event building units will be looking at the raw data in parallel and we able to exchange trigger information among them and also with similar units looking at the SP modules.

Any cables associated with DP photon system are described in the DP-Electronics/Photon interface document. Any cable trays or conduits to hold the DAQ/DP-Electronics cables are described in the LBNF/Technical Coordination interface documents and currently assumed to belong to Technical Coordination

Signals:

The DP-electronics is supposed to provide data in continuous streaming (12 bits at 2.5 MHz sampling) of all the charge readout channels over the 10 Gbit/s links. Each 10 Gbit/s link will be used to stream the data of 640 charge readout channels. The links will be operated as standard Ethernet links. The data streaming will be performed at constant rate without zero suppression and by applying lossless compression, derived from an optimized version of the Huffman algorithm. Given the noise characteristics and S/N ratio of DP electronics (RMS noise around 1 ADC count) a compression factor of 10 is expected. Blocks of data will be formatted in UDP packets which will also contain time stamps in the common WR time-base. The typical occupancy of a 10 Gbit/s link is expected to be 1.8 Gbit/s for each one of the 240 charge readout links and 4.7 Gbit/s for the 5 light readout links (sampling in normal conditions also at 2.5 MHz with 14 bits dynamics). Light readout may also operate with a sampling finer than 2.5 MHz in special runs devoted to measure the slow component of the scintillation light for purity measurements. Data transmission latency over the 10 Gbit/s network is expected to be at the level of few us, negligible with respect to the size of the memory buffers on the triggering farm.

More details are described in the document "DP-FE Electronics and DAQ interface aspects". The Data flow will be checked with the exchange of control UDP packets among the DAQ and the DP-Electonics AMC FE-units. This check will be periodically performed for fixed periods in order to make sure that the data streaming is proceeding smoothly and all FE units are aligned. The format and the frequency of exchange of control packets has to be defined.

Software: The software interface between DAQ and DP-electronics includes the software dealing with the data formatting in UDP packets, compression/decompression and exchange of control packets. The basic libraries will be provided by the institutions of the DP-Electronics consortium, which are also committed to the DAQ consortium.

Installation: The DP-electronics consortium will take care of the installation down to the optical fibers included.

Commissioning: DAQ and DP-electronics will provide staffing for common commissioning of the system including the DP-electronics and DAQ.