ATHENA DAQ Proposal

September 30, 2021

1 ATHENA data acquisistion system

The EIC collider will provide eP and eA collisions at rates up to 500Khz with potential collisions occurring in bunches separated by 10ns. Athena will digitize hit position, charge and timing signals originating from nearly 30 distinct detectors using a variety of front end technologies including Silicon Photo Multipliers (SiPMs), Monolithic Active Pixel Sensors (MAPS), DC and AC coupled Low Gas Avalanche Detectors (DC-LGADs and AC-LGADs), Large Area Pico-Second Photon Detectors (LAPPDs), photomultiplier tubes (PMTs), and MPGD technologies such as Micromegas, Gas Electron Multipliers (GEMs). The signals will be zero-suppressed, digitized and aggregated using front end boards containing a variety of ASICs and FPGAs each of which will require power, cooling, configuration and clock signals. The primary function of the DAQ system will be aggregate data and record all collision related hits. The system must also control, configure, and monitor the acquisition of data and ensure data quality.

2 A streaming Data Acquisition system

The Athena DAQ system will be a streaming DAQ system following the scheme outlined in the Yellow Report. A global timing system is needed to syncronize the system with the bunch struction of the EIC. The Front End Link eXchange (FELIX) boards are used as a basis to provide common interface between the FEBs and the commodity DAQ computers. These boards are capable of transferring data to the DAQ computers and of transmitting clock and configuration information to the FEBs. A farm of approximately 40 computers on a 100gbps ethernet network is needed to read out the FELIX boards, reduce the noise and send the data to long ter storage. An additional farm of 30 computers with 3000 CPU cores could do reconstruction of events for Q/A and as a first pass of data analysis.

3 Requirements and expected performance

The Athena DAQ should write out all collisions provided by the collider to the detector at rates up to 500kHz. The global timing will be synchronised to the bunch timing with a resolution of 10ns. The digital data to the FEBs could have data volumes as high as 15tbps. This data volume will need to be reduced to a level of 100gbps for long term storage without losing detector hits that arise from beam collisions.

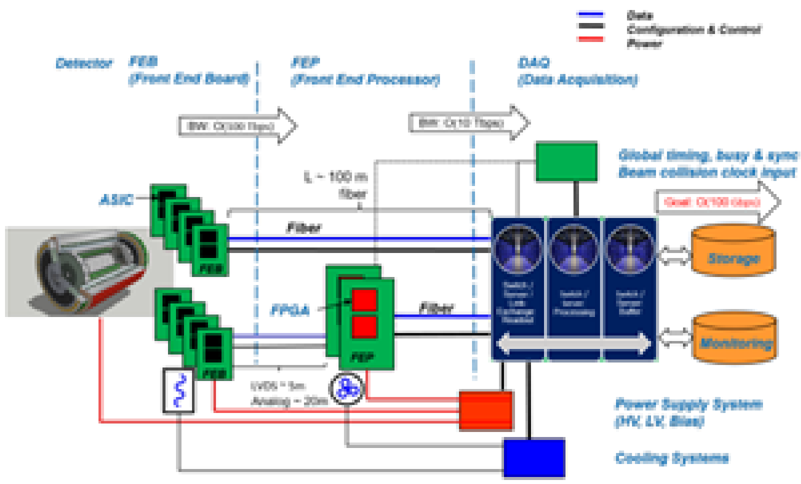
4 Limitations if any for EIC physics

The proposed Athena DAQ system will allow Athena to readout the full spectrum of events accessible to it's detectors.

5 Discussion of Risks and RD needs

The biggest challenge to the goal of fully reading out the Athena detector with no deadtime will be the dark currents from the SiPM readout as high as 3kHz per pixel. This dark current is indistinguishable from signals from single photons. We hope to reduce this by an order of magnitude in the FEBs by applying timing cuts relative bunch crossing time. It may be possible to further reduce this volume using machine learning techniques in the FPGA's of the FELIX boards. In the DAQ computers it will be possible to apply a software trigger to these detectors. Requiring a collision to be present will provide a data reduction of at least 200, allowing Athena DAQ to readout all collision data to tape.

The largest potential risk of the system is unexpectedly high noise in any detector, or the inability to reduce the noise in the SiPM detectors with single photon thresholds. One factor mitigating this risk is that the architecture of the system does not eliminate the possiblity of providing hardware trigger signals to specific detectors resulting in a hybrid triggered-streaming DAQ system. The potential avenues of data volume reduction at each stage will be the main RD required. There will be significant development required to integrate each detector with the FELIX board.


Detector
FEB
(Front End Board)
FEP
(Front End Processor)
DAQ
(Data Acquisition)
Global timing, busy & sync
Beam collision clock input
L ~ 100 m
fiber
ASIC
Fiber
FEB
FPGA
Fiber
FEP
Storage
Monitoring
LVDS ~ 5m
Analog ~ 20m
Power Supply System
(HV, LV, Bias)
Cooling Systems


Detector Ra