THE CERN n_TOF FACILITY DATA ACQUISITION SYSTEM

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The CERN neutron time-of-flight facility n_TOF (https://ntof-exp.web.cern.ch) features a white neutron source produced by spallation through 20 GeV/c protons produced by the PS and impinging on a lead target. The facility, aiming primarily at the measurement of neutron-induced reaction cross sections.

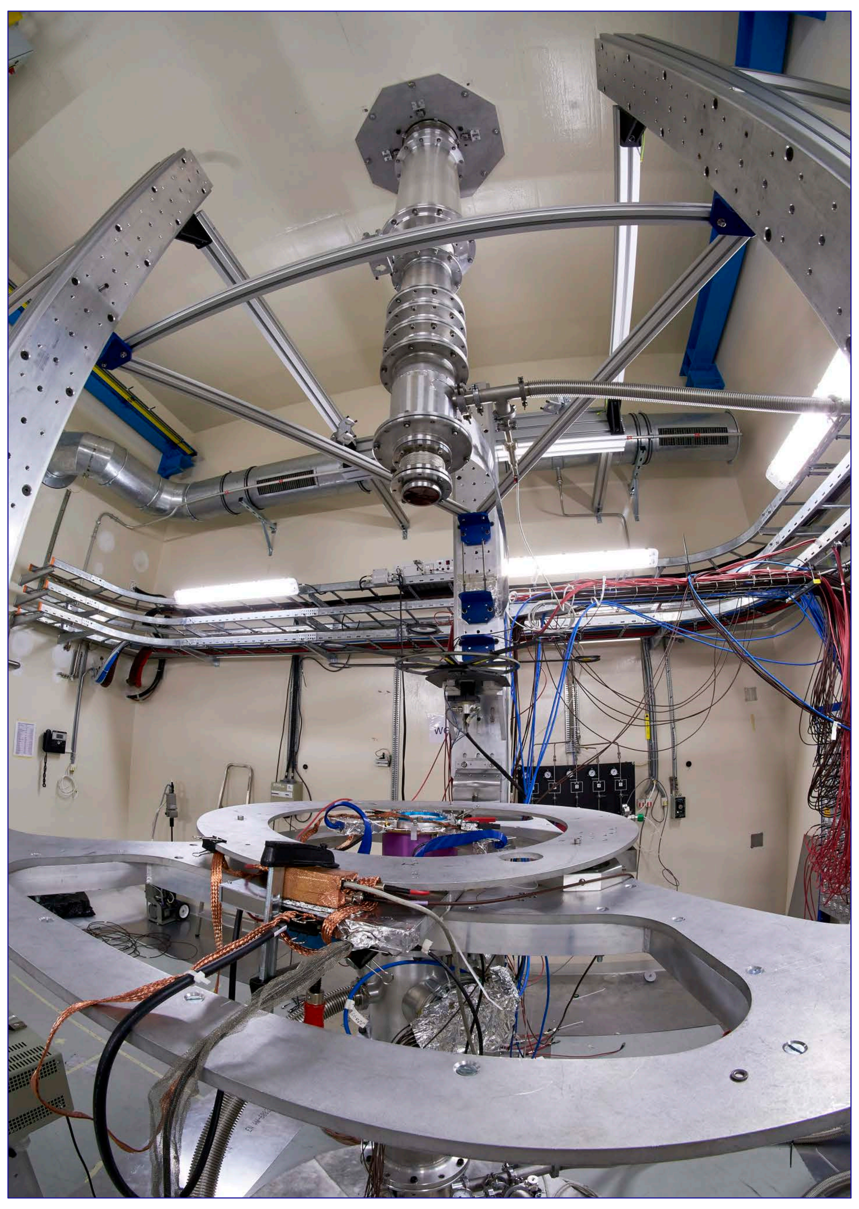

Figure 1: nTOF DAQ Experimental Area 2

n_TOF DAQ REQUIREMENTS

The n_TOF DAQ measurement application consists in digitally acquiring detectors output signals to analyse in time domain. The PS timing signal triggers the acquisition. The data samples are transferred on the host controller's memory in less than 1.2 second. Data are stored permanently on CASTOR (CERN Advanced Storage).

The architecture is modular with different ADC multichannel cards, distributed on several chassis equipped with a host controller running Linux CentOS 7 (DAQ units). The key parameters of the digitizers are:

- ADC front-end
- ADC resolution and sampling frequency
- On board memory size
- Card Data interface

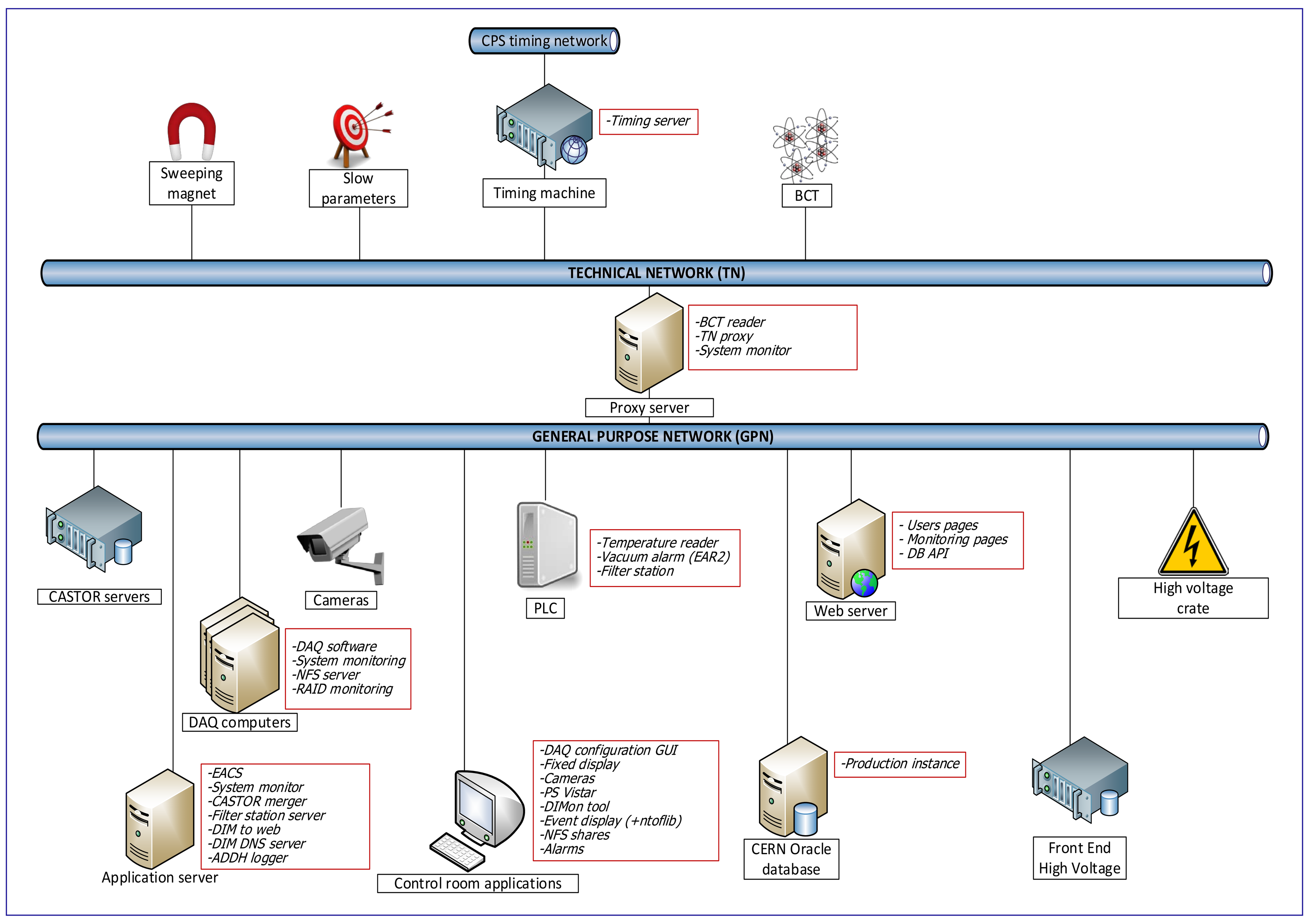

Figure 2: DAQ unit hardware architecture

n_TOF DAQ COMPONENTS

The global DAQ hardware architecture for each experimental area is depicted in figure 1. Data acquisition is done through **DAQ units** by using SPDevices cards (i.e. table 1). Raw data are stored locally in each machine on a high speed storage before being transferred to the CERN Advanced Storage (CASTOR). Figure 3 shows the DAQ unit hardware architecture while figure 4 the memory management of the acquisition software. The DAQ is synchronized with the operation of the PS accelerator, for example by the proton beam extraction towards the n_TOF target through the **timing machine** connected to the CERN timing network. Caen SY4527 **High Voltage power supply** mainframes are used to supply the detectors in each experimental area. The neutron flux production as well as the physics experiments rely on the control and monitoring of devices and/or critical experimental area parameters. In particular: **Sweeping magnet** (a resistive magnet used to eliminate charged particles from the neutron beam. **Filter box** (a motorized mechanical support to position in the neutron beam up to 8 different filters to absorb neutrons at specific energies). **Experimental area temperatures and ventilation door switches**

Requirements	ADQ412	ADQ14
Resolution	12-bit	14-bit
Full Scale Input Range (FSR)	0.1-5Vpp	0.05-5Vpp
Sampling frequency & N. of channels	1.8GS/s 4-ch 3.6GS/s 2-ch	1GS/s4-ch
On board Memory Size	175MS/ch	256MS/ch
Bandwidth (-3dB)	1.3GHz	400MHz
Adjustable input bias	+-100% FSR	
Bus Interface	PCIe GEN2x8	
Trigger	Internal/External	
Scientific Linux drivers	Yes	

Table 1: n_TOF DAQ cards characteristics

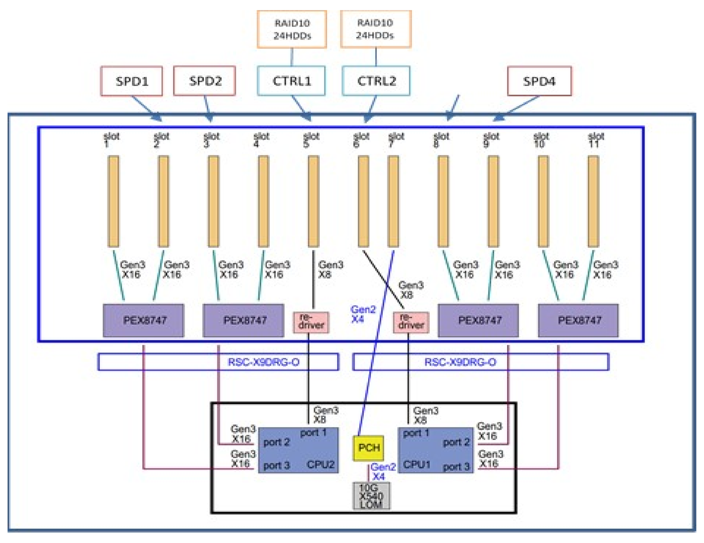

Figure 3: DAQ unit hardware architecture

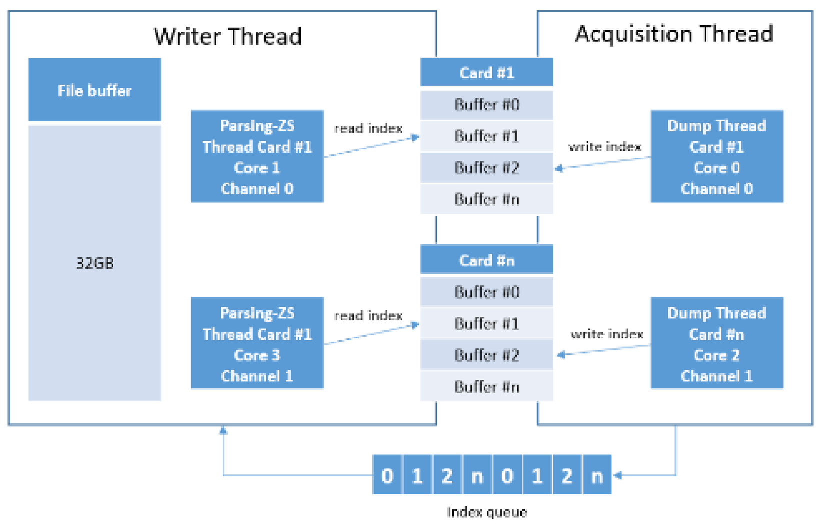

Figure 4: DAQ unit memory management

CASTOR Merger

The CASTOR merger is the application responsible for the re-building of the event and for the optimized transfer of the acquisition data from the DAQ units and the EACS to CASTOR. The application, once opened an xroot connection towards CASTOR, ensures a continuous data stream collecting the data through NFS from each DAQ unit and performing the merging of several raw data files.

n_TOF MIDDLEWARE

The nTOF middleware is based on DIM (Distributed Information Management). DIM is based on the Client/Server paradigm; Servers provide services to clients. XML was used to format the service data in the DIM data set. DIM client/server communication has been integrated with a synchronous handshaking mechanism. A special command service coupled with an acknowledge service has been created. As soon as a new command is sent and received by the server, it sends back to the client the acknowledged with the proper command identifica-tion. The n_TOF middleware is based on a combination of DIM clients and servers deployed on the different components.

EACS

The Experimental Area Coordination System (EACS) is the DAQ coordinator. It connects to the DB through OCCI whilst to the GUI and each DAQ units through the n_TOF middleware. It receives commands and settings from the GUI and dispatches them to the related DAQ units. The changes, if correct, are saved in the DB.
The EACS exploits the crucial function to synchronize the acquisition data of all the machines. The EACS is notified by the timing server through the middleware when a new trigger has been fired. The EACS is also responsible for the creation of the index files. They contain the information concerning the run, the cards' configuration, and the data of the event (i.e. beam intensity)

DATABASE

The n_TOF Database is an Oracle instance and stores critical information for the DAQ operation and the subsequent data analysis.

The information are grouped as:

- The hardware settings
- The operational information
- The organisational data

THE GRAPHICAL USER INTERFACE

The GUI (figure 6) is the only application used by the shifter to operate the DAQ. The main interface is characterized by the following main functionalities:

- Experimental Area configuration: the operator can specify the material of the sample under study, the type of radioactive source used or select a particular filter to insert in the neutron flux, among other options.
- DAQ configuration
- Physics run description: the shifter inserts the title and the description of the run as plus update the logbook
- Operation follow-up: after launching the DAQ acquisition, the GUI helps the shifter to monitor the correct operation. The list of the validated events and the related value of the cumulated protons are also updated online.

The GUI directly accesses the n_TOF Database using JDBC to store and retrieve all the data. The communication with the DAQ units is performed through the EACS.

n_TOF WEB MONITORING

The DAQ operation status and performance monitoring is ensured through customized web pages.

As seen in figure 5, the core of the web monitoring is the application named DIM2WEB. It collects all the significant information of the DAQ status and redirects directly on a web socket the requested DIM data set.

The monitoring system enables users to keep an eye on the experiment's global state. This way, any alarms or unexpected behavior can easily be repaired / noticed, avoiding bigger issues.

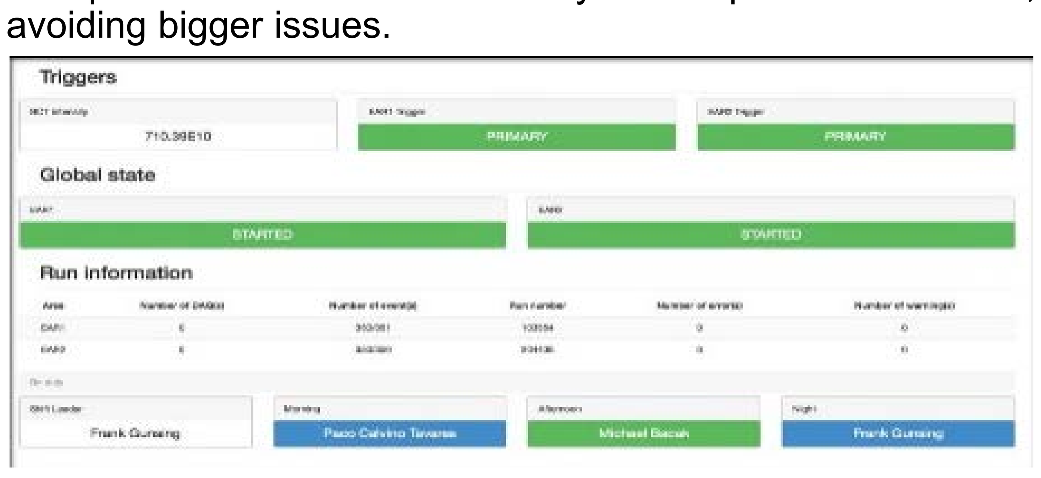

Figure 7: n_TOF DAQ main web monitoring page

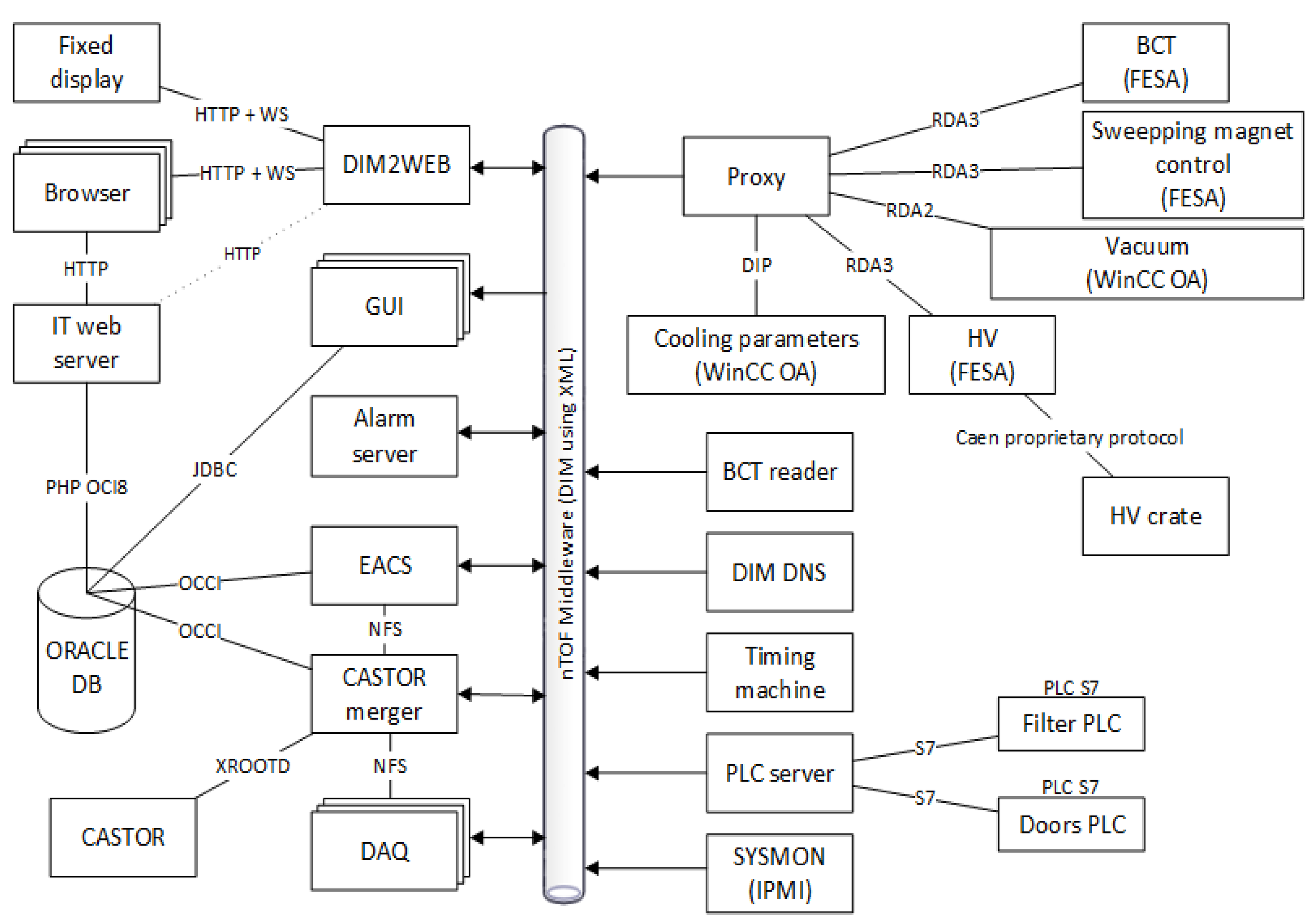

Figure 5: nTOF DAQ software architecture

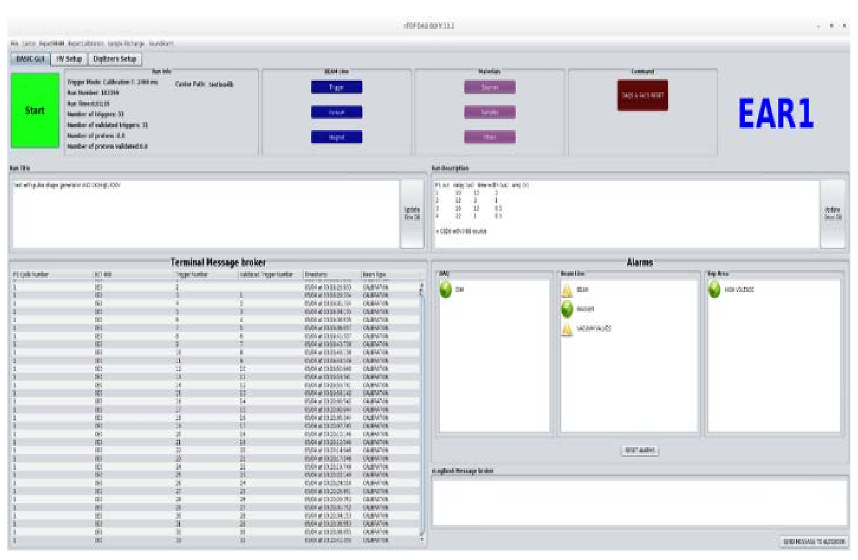

Figure 6: nTOF GUI main panel

DAQ OPERATIONAL EXPERIENCE

The new n_TOF DAQ system has been in operation since 2015 and has worked 24/7 for roughly 10 months each year. 1 PB/year of data acquired and transferred to CASTOR for both experimental area. The data transfer to CASTOR optimization implemented in the CASTOR merger has guaranteed to reach the physical limit of the network bandwidth (i.e. 1.2 GB/s). The operation reliability has been improved thanks to a proper extensive commissioning phase performed during each shutdown period. The diagnostic and management tools developed ad hoc allowed the operator in shift to prevent failure and/or to quickly resolve most of the issues on his own. This has significantly reduced the n_TOF DAQ downtime. The n_TOF DAQ 2017 operation is estimated to have an uptime of 98.9 %.

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