Data Quality and Run Selection for the SNO+ experiment

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Abstract. The SNO+ detector main physics goal is the search for neutrinoless double-beta decay, a rare process which if detected, will prove the Majorana nature of the neutrinos and provide information on the absolute scale of the neutrino absolute mass. Additional physics goals of SNO+ include the study of solar neutrinos, anti-neutrinos from nuclear reactors and the Earth’s natural radioactivity as well as Supernovae neutrinos. Located in the SNOLAB underground physics laboratory (Canada), it will re-use the SNO experiment infrastructure with the 12 m diameter spherical volume filled with 780 tons of Te-loaded liquid scintillator. A short phase with the detector completely filled with water has started at the end of 2016. It will be followed by a scintillator phase expected to start at the end of this year. Continual careful monitoring of the detector state such as its hardware configuration, slow control information, data handling and triggers is required to ensure the quality of the data taken. Several automatic checks have been put in place for that purpose. This information serves as input to higher level run selection tools that will ultimately perform a final decision on the goodness of a run for a given physics analysis.

1. The SNO+ experiment

The SNO+ experiment re-uses the SNO ~9300 photo-multipliers (PMTs). The detector was upgraded with a new hold-down ropes system, new data-acquisition and readout systems, and modifications of its water plant. New scintillation and tellurium purification plants are also being completed at present. The detector (Figure 1) is constituted of a geodesic steel structure of 17 m diameter which supports the PMTs. Inside, a spherical acrylic vessel of 6 m radius holds the media. The acrylic vessel is shielded by 7 kt of pure water which fills the entire cavern.
Additional rock shields composed of norite and granite/gabbro are surrounding the detector located 2 km underground in SNOLAB (Canada). SNO+ will have several experimental phases: a water phase, a scintillator phase with 780 tons of liquid scintillator and a scintillator loaded phase with 1.33 tons of $^{130}\text{Te}$ ($0.5\%$ nat Te). The detector is equipped with a set of different calibration systems which are composed of deployable radioactive sources (provide an estimation of the reconstruction efficiency and the systematics uncertainties) and optical systems (measure the PMTs response and media properties such as the attenuation and scattering coefficients). The detector is currently filled with water and taking data since the beginning of 2017. See [1, 2, 3, 4, 5] for more detailed information.

Figure 1. The SNO+ detector.

2. Low level data quality checks

The low level data quality checks ensure that the detector state and the laboratory environment conditions are good for data-taking. Monitoring of the trigger conditions is provided as well as verifications of the correct data-packing and event building. Among the available information, the detector state (Figure 2) is displayed on a web page on a run per run basis. It provides information on the detector high voltage status, the channels settings such as the enabled triggers and the active alarms. Additionally a set of views which are querying database information has been designed. As an example, one can verify a given run type (e.g. physics or calibration) and duration as well as special detector conditions such as whether water was being recirculated during that run (Figure 3). The information is collated into a low level data quality (DQLL)

Figure 2. Detector state checks.

table which final design is not frozen yet. One can see an example of the information provided by this table in Figure 4.
For a run to be considered as good is should at least pass the following DQLL checks:

- Physics run of duration greater than 30 minutes
- Compensation coils should be on
- No disruptive activity on-going above the detector
- All crates have high voltage on at their nominal value
- No data readout errors

3. High level data quality checks

The high level data quality checks ensure that the data are good for physics and calibration. Complementary to the low level data quality checks, the data are unpacked and statistics over the recorded events and triggers is performed. The information is recorded in a high level data quality (DQHL) table. Additionally a set of histograms is provided as input to the run selection group in charge of deciding of the goodness of a run. Some example of the data quality checks histograms is provided in Figures 5 and 6. Additional information can be obtained from the DQHL such as PMTs coverage maps (Figure 7).
For a run to be considered good it should at least pass the following DQHL checks:

- correct physics triggers enabled
- triggers working correctly
- event rate within expected rate
- Global Triggers IDs (GTIDs) increase
- no missing GTIDs
- no GTIDs out of order
- clocks in agreement
- event timestamps in run boundaries
- minimum PMT coverages

4. Run Selection

The Run Selection team is a small group in charge of ensure the quality of the data taken on a run by run basis and in near real-time. The team is developing automated tools to retrieve the data-quality low/high level information. These tools are in charge of applying goodness criteria to the DQLL/DQHL values to decide the goodness of a run. Regular feedback to detector operators is provided to improve the detector stability and the checks of the monitoring tools. This group receives feedback from the different analyses involved on the required criteria. An iterative process is helping thus refining the run selection criteria. As part of the automated tools, a run view (see Figure 8) retrieves the DQLL/HL information and applies the automated checks once the run is processed. The statistics tools for run selection and livetime calculation are under development.

![Figure 7. PMT's coverage map.](image)

![Figure 8. Automated run view.](image)
5. Conclusion
The SNO+ data-quality low-level and high-level framework offers a constant monitoring and persistent information on the detector status, data goodness and slow-control on a run per run basis. A set of automated tools are being developed and tested to filter out runs which are not qualifying for SNO+ analyses in the water phase. The Run Selection team is in charge of ensuring on one-hand good exposure to neutrino physics and nucleon decay, and on the other hand making sure the data quality meet the analysis requirement. The preliminary physics runs statistics from May 4th 2017 to July 16th 2017 was of 57 days of physics data-taking.

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References
[1] E. Caden, “Status of the SNO+ experiment”, Talk presented at TAUP 2017, in these Proceedings.
[2] J. Rumleskie, D. Sinclair, “Supernovae and SNO+”, Poster presented at TAUP 2017, in these Proceedings.
[3] I. Coulter, “Search for invisible nucleon decay in the SNO+ experiment”, Poster presented at TAUP 2017, in these proceedings.
[4] K. Singh, “Underwater photometry system of the SNO+ experiment”, Poster presented at TAUP 2017, in these proceedings.
[5] D. Chauhan, O. Chkvorets, “A sensitive assay technique for $^{210}$Pb in water”, Poster presented at TAUP 2017, in these proceedings.