Time dependent instrument parameters

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1 Introduction

Instruments at the European Spallation Source will record parameters automatically via an EPICS layer on which all values update at a fixed frequency, whenever they change by a configured amount, or some combination of the two. The parameter changes will be forwarded as flatbuffer messages to a Kafka topic, to be collected at file-writing time for long-term storage in raw data files.

Some or all of these time-dependent instrument parameters are necessary for the conversion of raw data into a more-useful form via a data-reduction process. Since neutron data at ESS is recorded and stored as event times it is possible, and may be necessary, to uniquely identify the state of any given parameter for every neutron event.

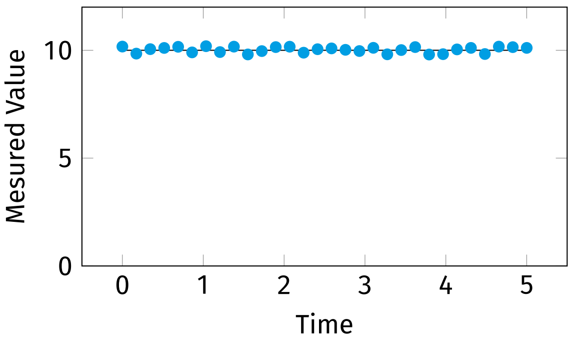

Figure 1: A steady-state parameter

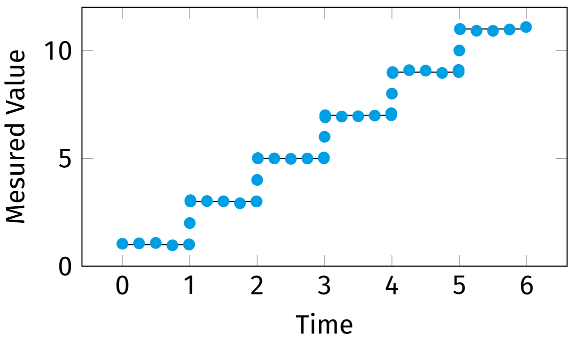

Figure 2: A stepwise scanned parameter

2 Parameter time dependence

There are four main classes of time-dependence for instrument parameters, detailed below.

2.1 Steady-state

Some instrument parameters may remain unchanged during the measurement period stored in a raw data file. Such parameters may have multiple recorded values if they are updated at a fixed frequency, or if their value is unstable with random fluctuations about a mean value. In either case, the average of all records in the file is sufficient for reducing all neutron event data in the file. Figure 1 illustrates a steady-state parameter for which only the average (black-line) value is required.

2.2 Stepwise scans

Some raw data files may cover time periods during which one or more parameters are intentionally changed, typically referred to as scans. Easily-controlled parameters, like motor positions, are often changed in discrete steps. Before continuous event-mode data collection, all such parameters would be changed at once, the instrument control software would then wait for a steady-state and then start data collection. To mimic such experiments, it is necessary to identify time-periods where stepwise-scanned parameters are constant. Figure 2 illustrates a stepwise scanned parameter's time series values, plus the constant regions as black solid lines.

2.3 Continuous scans

Motors or sample environment paramters may be changed continuously during a scan. This may be done when the steady-state control of a parameter is difficult, or time-

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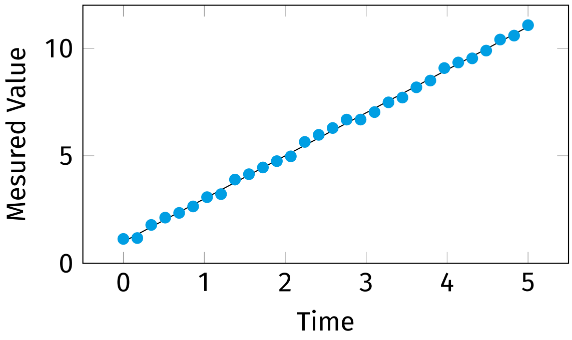

Figure 3: A ramped parameter

consuming, but determining its instantaneous value is easy. Such scans are often called ramps. Depending on the type of parameter and user preference for data-reduction, it may be necessary to find time-periods during which the parameter is pseudo-constant or to linearly interpolate the parameter value between measurement times for every neutron event. Figure 3 shows a continuously scanned parameter, for which a linear approximation is valid, the black line which fits the total time dependence may not always be possible or desirable for real data.

2.4 Perturbations

A less common measurement mode involves periodic perturbations of one or more sample parameters, often referred to as pump-probe measurements. In such experiments, the parameters are sampled at a frequency much-higher than the neutron source frequency and it is necessary to identify the instantaneous parameters values for every neutron event.

3 Requirements

Data reduction for all instruments and all measurement techniques will require information about instrument parameters, so a common solution to handle their time dependence is desired. A single solution that always uses linear interpolation of parameter measurements to identify instantaneous values for every neutron event could be used to reduce neutron data collected in all cases mentioned above. Such a solution, however, likely has significant overhead and may not be suitable for those cases where a lower-overhead solution is feasible.

To handle all measurement cases, a user-selectable per-parameter configuration is necessary. Three possible choices for the user could be:

1. The average value of *static* parameters are used in data-reduction. When a datafile is loaded, the average and variance of any such parameter can be calculated and retained for use.
2. Stepwise changed or pseudo-constant periods of continously-changed parameters can be *binned* in time. Using a per-parameter status-log and/or user-specified binning parameters, the pseudo-constant time-periods can be identified and their measurement averages and variances determined when a datafile is loaded.
3. The *linear* interpolation of the measured values of a parameter can be used to estimate the instantaneous value of continuously scanned or periodically perturbed parameters. The interpolation function for such parameters can be constructed when the datafile is loaded for later use in the data-reduction.

In all cases, a functional interface that takes an absolute time as input and returns the stored average, binned, or linear interpolated parameter value could be used. A single way of accessing parameter values would simplify data reduction workflows at the possible cost of higher resource use.