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TEACHING AN OLD ACCELERATOR NEW TRICKS*

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Abstract

The Argonne Tandem Linac Accelerator System (ATLAS) has been a National User Facility since 1985. In that time, many of the systems that help operators retrieve, modify, and store beamline parameters have not kept pace with the advancement of technology. Investigation and development of a new method of storing and retrieving beamline parameters resulted in the installation and testing of a time-series database as a potential replacement for the traditional relational databases.

INTRODUCTION

In the operation of ATLAS [1], there is a need save and restore operating values of beamline devices. These stored profiles, which are stored on a per experiment basis, allow operators to restore the beamline to a known state. The ability to restore a similar profile, or scale a profile base on the ion species allows for more rapid tuning of the machine for a new experiment.

To save and restore beamline profiles, ATLAS operators currently use a proprietary commercial off-the-shelf (COTS) relational database (RDB) hosted on a PC. This PC-based database interacts with the control system in a limited way by querying another COTS relational database which resides on an OpenVMS [2] platform. On the OpenVMS platform, a program periodically queries a subset of the control system channels, and stores their values in a table in the OpenVMS-based RDB, for the PC to eventually retrieve and store. The PC-based RDB has been moved to End of Life (EOL) status and is no longer supported by its developer. Additionally, there is a strong desire to move off of the OpenVMS platform as well as the proprietary RDB it hosts.

TIME SERIES DATABASE

A traditional relational database uses a collection of related tables, with each table having a key to organize rows of data, and a fixed number of columns per table. A time-series database (TSD) differs in a few key ways from a relational database. The main difference is that a TSD always uses time as its key. A nice feature of some TSDs, is that the number of columns is not fixed. Using a specific time seemed like it would be a novel way to be able to store and retrieve the value for every channel in the control system of ATLAS. This means that every control channel and every read-back channel would be stored. The beamline profile would then be a subset of the data stored at a given point in time. This arrangement would allow secondary programs to access all of the ATLAS control system data. An operator-facing system is planned that would store meta-data about an experiment, such as ion species, experiment number, energy level, etc. This operator system would then simply point to a specific time in the TSD to recall all of the beamline parameters about that experiment.

TESTING

InfluxDB [3] was selected due to its self-hosted Open-Source version availability as well as the simplicity of installation and setup. A program was written to periodically gather all accelerator control parameters, as well as read-back values, in the control system and store them in the time-series database. This resulted in over 13,000 distinct data points, captured at 5-minute intervals. While this seemed like a lot of data to capture, InfluxDB did not have any issue keeping up. This testing uncovered bugs in a specific part of the underlying software in the control system and has been halted until those issues can be resolved.

Graphing of the captured data is being done on Grafana [4], a self-hosted Open-Source version is available that co-exists well with InfluxDB as the back-end. Grafana made visualizing the data simple and flexible.

A second test captured 35 channels on a 1-minute cadence on the ATLAS Californium Rare Isotope Breeder Upgrade (CARIBU) [5]. This has been reliably gathering data for several months. These measurements quickly became used in regular operation of CARIBU, with physicists creating their own specialized graphs. See Figs. 1-3 Due to the success of the second test, a number of other channels have been added to the InfluxDB in an ad hoc manner in an effort to aid various teams in recovering from a power outage. See Figs. 4 and 5 for cryogenics displays.

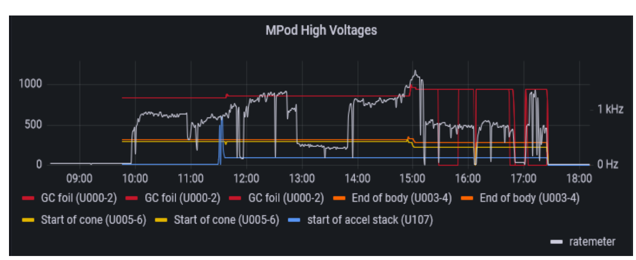

Figure 1: CARIBU High Voltage Display.

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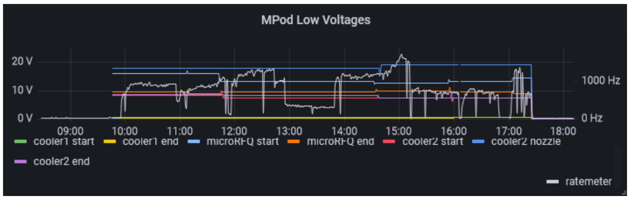

Figure 2: CARIBU Low Voltage Display.

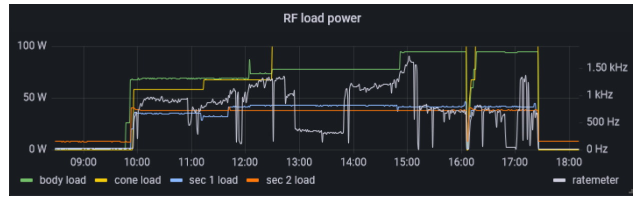

Figure 3: CARIBU RF Load Power Display.

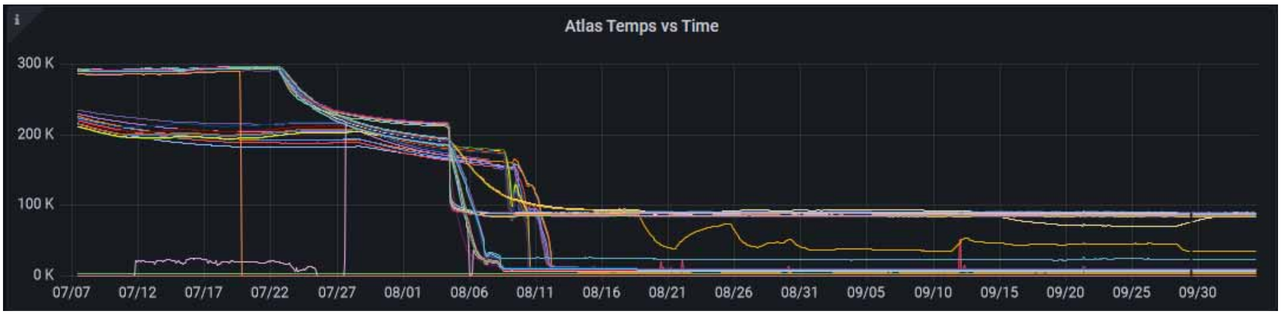

Figure 4: Atlas LINAC cryogenic system temperatures during cooling process.

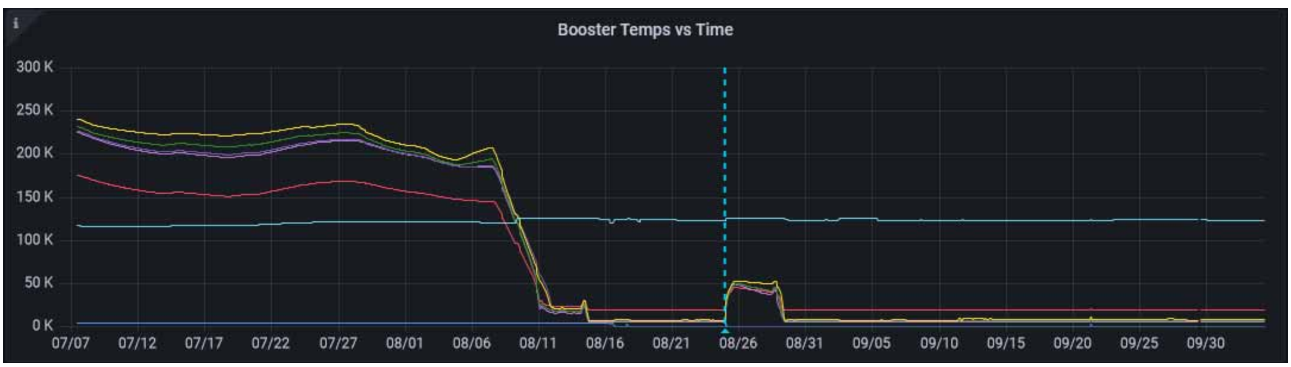

Figure 5: Booster LINAC cryogenic system temperatures during cooling process.

FINDINGS

The initial testing proved successful in the ability to capture, store, and retrieve data from the ATLAS control system. What was surprising was how quickly after introduction of the system that members of the operations team requested specific data be captured and displayed. These requests help aid in diagnosing a magnet power supply on the verge of failure. New displays also helped answer questions about beam stability, by monitoring the stability of magnet currents along the ATLAS Material Irradiations Station (AMIS) beamline.

CONCLUSION

While the goal of this project was to test out ideas and tools while replace aging systems, it also showed the utility of such a system not only to the operators, but to researchers as well. The use of modern graphing tools to generate new insights into operating the accelerator, and has opened the door to building large data sets suitable for Artificial Intelligence and Machine Learning applications.

REFERENCES

[1] ATLAS, `https://www.anl.gov/atlas`

[2] “OpenVMS”, `https://vmssoftware.com/`

[3] “InfluxDB”, `https://www.influxdata.com/`

[4] “Grafana”, `https://grafana.com/`

[5] CARIBU, `https://www.anl.gov/phy/californium-rare-isotope-breeder-upgrade-caribu`