

# TURNING LOGBOOK DATA INTO OPERATIONAL INSIGHT WITH A NEW STATISTICS SERVICE AT GSI AND FAIR

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## Abstract

It is common practice during accelerator operation to continuously document all relevant machine states and activities. At GSI Helmholtz Centre for Heavy Ion Research (GSI), this is done using an electronic logbook developed in-house and adapted to the specific requirements of accelerator operations, allowing shift crews to record failure events, setup times, and other important information in high detail. A new service, currently under development, aims to simplify the on-demand access to relevant statistics and is being prepared to include data from the Facility of Antiproton and Ion Research (FAIR) as its operations gradually commence in the upcoming beamtimes. This service is built as two layers: a backend layer using the Micronaut framework, which communicates with the database to retrieve logbook entries and calculate statistics, and a frontend layer using the Angular framework, which handles user requests and provides graphical representations of the statistics and their raw data. This paper introduces the new statistics service as an assessment tool based on operational data at GSI and FAIR.

## INTRODUCTION

The operational success of large-scale facilities like GSI Helmholtz Centre for Heavy Ion Research (GSI) [1] requires close coordination between multiple departments and technical groups. Precise and continuous documentation ensures that operational data remains accessible and reliable across all teams, which allows for the maintenance of efficient communication between complex, interacting areas such as beam diagnostics and physics, technical infrastructure, and control systems.

At GSI, shift crew operators use OLOG [2], an electronic logbook tool developed in-house to continuously record events that may influence beam delivery or machine performance. These include failure events, machine setups, system adjustments, and unusual operational conditions. By maintaining detailed records of such events, operators, engineers, analysts and coordinators can later revisit any operational period, evaluate performance trends, and identify recurring issues that highlight weaknesses in the facility in need of improvement that might otherwise go unnoticed. A complementary KPI-based approach for quantitative beam-based performance assessment at GSI has recently been introduced in Ref. [3]. Results are presented in Ref. [4].

In addition, documentation becomes increasingly important as facilities expand. With the gradual development of the Facility for Antiproton and Ion Research (FAIR) [5], the complexity and scale of accelerator operations will grow

significantly. This increasing operational complexity is also reflected in the FAIR Control Centre concept, which was developed to support the larger and more intricate operational scope of the FAIR/GSI accelerator complex [6, 7].

## MOTIVATION

### *Previous Solution to Generating Statistics*

At present, operational documentation at GSI is managed through the OLOG web application (see Fig. 1). This system allows operators to manually record events in an electronic logbook. Up until its last version, the OLOG web application included a feature for generating statistical summaries. Users were able to export tables containing calculated statistics based on the logbook entries stored in the database. These tables would provide information about events as documented by the operators. However, concatenation of statistics over larger time frames had to be done manually, leaving room for error and incorrect conclusions, as previously also highlighted in other institutes [8]. Furthermore, although the system did provide a full event export, an option to export data relevant only to a specific statistic did not exist.

### *Concept for New Statistics Service*

The new statistics service seeks to provide fast and convenient access to accelerator performance data by offering a unified, automated interface for statistical generation. The system is designed to allow users to request specific statistics for a chosen time range and immediately receive both the calculated results and the underlying data.

Once a statistic is selected, the service runs through several steps to first retrieve the necessary entries from the OLOG database. Next, the system processes the data and calculates the requested statistics. Finally, the results are displayed graphically and accompanied by the raw data used in the calculation.

Providing both visualizations and raw data offers several advantages. The automatic graphical representations allow users to quickly use analyses in meetings or presentations, and to visualize the collected data and identify patterns or anomalies in the data, while access to the raw data enables more detailed analyses when needed.

**Requirements** Aside from ensuring accurate and reliable statistical calculation, the design of the new service is guided by three main objectives.

First, the system must be easy to use. The web interface must remain intuitive and require minimal training, enabling both technical and non-technical users to extract statistics with minimal effort.

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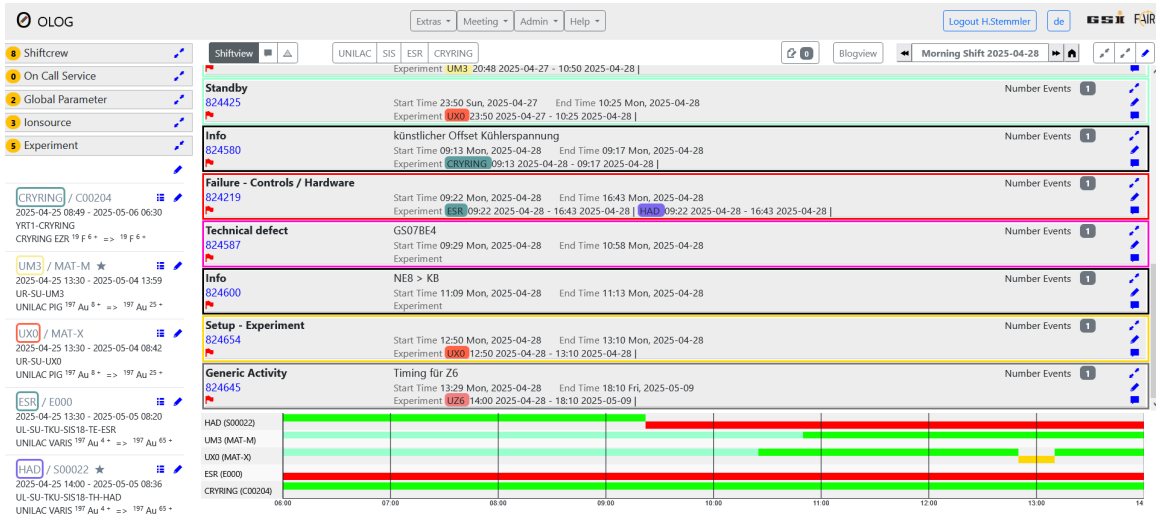


Figure 1: User interface of *OLOG*, the electronic logbook system used at GSI and FAIR to document operational data.

Second, loading and computation times must remain low despite large data volumes, ensuring results are generated within seconds.

Third, the system should produce high-quality graphical outputs. Clear and customizable visualizations improve the interpretation of the statistics and allow the results to be used in reports, presentations, or documentation.

**Restrictions** Despite its advantages, the new system also adheres to certain limitations. As the current *OLOG* database has been in use since 2016, earlier accelerator events are not retrievable by the service. Data from 2006 onwards is available on a different system, however the entry types do not necessarily correspond to the current *OLOG* data structures. This limits the historical range of possible analyses.

Additionally, much of the data in the *OLOG* system is documented manually by operators. While this allows for detailed descriptions of events, it also introduces potential inconsistencies, as naming conventions or classification methods may have changed over the years, making automated analysis more challenging. A strict standard of how events should be documented is therefore crucial.

## IMPLEMENTATION

The new statistics service is implemented using a two-layer architecture consisting of a frontend layer using the Angular framework [9] and a backend layer using the Micronaut framework [10]. This separation improves scalability, maintainability, and flexibility.

### Technologies

**Front-End Layer** The frontend layer is implemented using the TypeScript-based framework Angular. This framework is widely used for building responsive and dynamic web applications. It provides a robust environment for handling user interactions, and is already being used in development of many other web applications at GSI.

### Availability Statistics (Weekly)

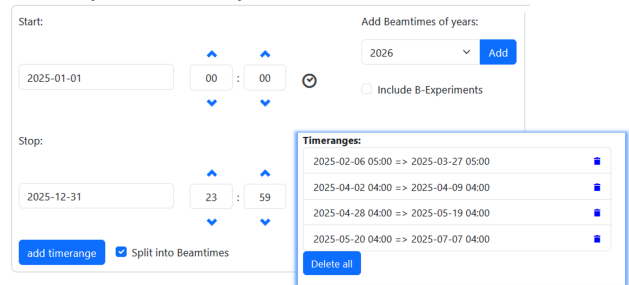


Figure 2: Static Angular component handling statistic and time range selection with the display of selected time ranges stamped in.

In the statistics service, the frontend is responsible for managing user requests. First, users specify a time range on a static Angular component as shown in Fig. 2 that carries over to all pages in the service. Beam time periods can be automatically specified by the system, but the user is also free to select multiple custom time periods adjusted to their needs. After selecting the desired statistic, the specified time range is sent to the backend layer described in the next section.

Upon receiving a response from the backend layer, the frontend generates graphical representations using the *D3* [11] package from the data. Figure 3 shows the graphic generated by *D3* for the selected statistic and time range specified in Fig. 2. Every graph is configured to display the corresponding statistic as accurate, comprehensive, and insightful as possible.

Finally, users can download each graph as an SVG file, all graphs in a ZIP file (if multiple graphs exist), and the raw data in a JSON format.

**Back-End Layer** The backend layer was developed as a Java microservice using the Micronaut framework, which is well suited for lightweight, high-performance services that interact with databases and external systems.

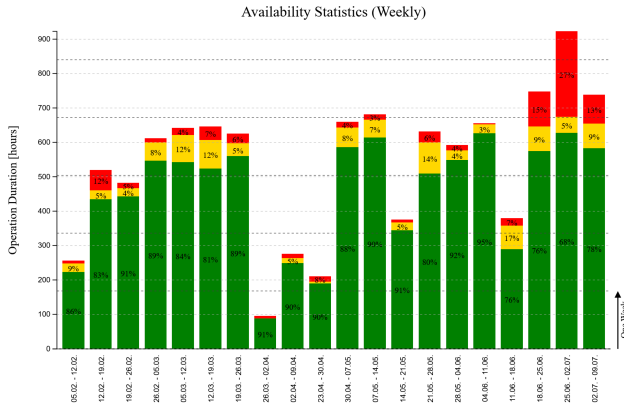


Figure 3: D3 generated SVG graphic of chosen statistic and time range as specified in Fig. 2.

As the backend layer receives requests from the frontend specifying the selected statistic and the desired time range, the service then retrieves the corresponding logbook entries from the OLOG database. The backend then processes the data entries and calculates the requested statistics. These calculations include aggregating event times, handling overlapping entries, grouping and sorting entries into appropriate categories or time frames, counting event frequencies and occurrences, and analysing operational durations.

Once the calculations are complete, the backend sends both the results and the raw data packed into response objects specifically configured to show the statistics to be displayed at first sight. As such, the response objects are converted into JSON files, that have the relevant information at first or second level, while the raw data the statistic was calculated from is then provided in deeper levels to the finest detail.

### Data

All calculations are based on event entries manually documented in OLOG by GSI operators. Each entry typically contains information such as the time of the event, its category, a short description, fault-causing devices, as well as affected machines and experiments, as displayed in Fig. 1. These reports are stored in a database the new statistics service accesses and uses as the basis of the calculations.

Because these entries are recorded in real time during accelerator operation, they provide a detailed record of machine activity, however they are also susceptible to human error as some entries are made during hectic in-shift moments. During weekly meetings, events documented since the previous meeting are reviewed and potentially revised to better reflect the reported incident in light of hindsight. This reduces errors and inaccuracies but does not guarantee complete correctness.

## RESULTS

Initial testing shows that the statistics service performs well and fulfils its intended purpose. During development, the system helped identify inconsistencies within the database, similarly to what was experienced in Ref. [12]. For example, certain naming conventions had changed over

the years, leading to variations in how events were recorded. Correcting these irregularities enhanced both the accuracy and consistency of future analyses, validating the service's usefulness as a diagnostic resource.

Another notable result is the system's performance. Despite retrieving thousands of logbook entries spanning over ten years, the service achieves loading times of only a few seconds. This gives confidence that expanding the database and the service with further development of FAIR won't have a big impact on the system's performance.

The automatically generated SVG graphs proved particularly practical, offering high-quality graphics that can be easily customised, scaled, or adapted to various formats without the loss of fidelity. These features make the tool valuable not only for internal performance tracking but also for inclusion in official reports or experimental run summaries.

## CONCLUSION

The newly developed statistics service provides a powerful and efficient tool for analysing accelerator operation data at GSI. By combining automated data retrieval, statistical analysis, and graphical visualization, the system significantly improves the accessibility and usability of operational data. The service also demonstrates strong performance and scalability, enabling the analysis of large datasets with minimal waiting time.

Future plans include linking the service to the upcoming archiving system under development at GSI. This will further improve the quality and completeness of the operational data, thereby increasing accuracy of the statistical analyses.

Overall, the system represents an important step toward more efficient data-driven evaluation of accelerator operations and will play a valuable role in supporting both current GSI activities and future operations at FAIR.

## REFERENCES

- [1] GSI Helmholtz Centre for Heavy Ion Research, <https://www.gsi.de/en/start/news>
- [2] P. Schuett *et al.*, "The GSI Operation Logbook OLog", presented at the 7th Int. Workshop on Accel. Oper. (WAO'10), Daejeon, Korea, Apr. 2010, <https://www-conf.kek.jp/wao/WAO2010/PDF/0-17.pdf>
- [3] O. Geithner *et al.*, "Introduction of key performance indicators for the GSI accelerator facility", in *Proc. 16th Int. Part. Accel. Conf. (IPAC'25)*, Taipei, Taiwan, Jun. 2025, pp. 604–606. doi:10.18429/JACoW-IPAC2025-MOPS008
- [4] O. Geithner *et al.*, "GSI Operation statistics in the FAIR Construction Phase (2012-2025): Trends, Failures and Lessons Learned", presented at the 17th Int. Part. Accel. Conf. (IPAC'26), Deauville, France, May 2026, paper WEP6127, this conference.
- [5] S. Reimann *et al.*, "FAIR commissioning - Towards first science", in *Proc. 16th Int. Part. Accel. Conf. (IPAC'25)*, Taipei, Taiwan, Jun. 2025, pp. 2495–2498. doi:10.18429/JACoW-IPAC2025-THBN2

- [6] M. Vossberg, K. Berkl, S. Reimann, P. Schuett, R. J. Steinhagen, and G. Stephan, “FAIR Control Centre (FCC) - Concepts and Interim Options for the Existing GSI Main Control Room”, in *Proc. 8th Int. Part. Accel. Conf. (IPAC'17)*, Copenhagen, Denmark, May 2017, pp. 1791–1794.  
[doi:10.18429/JACoW-IPAC2017-TUPIK047](https://doi.org/10.18429/JACoW-IPAC2017-TUPIK047)
- [7] K. Grigoryev, R. Baer, S. Reimann, and V. Kamerzhiev, “Commissioning of the FAIR Control Center”, presented at the 17th Int. Part. Accel. Conf. (IPAC'26), Deauville, France, May 2026, paper WEP6100, this conference.
- [8] P. Duval, H. Ehrlichmann, M. Lomperski, and J. Bobnar, “Automated Availability Statistics”, in *Proc. 11th Int. Workshop Emerging Technol. Sci. Facil. Controls (PCaPAC'16)*, Campinas, Brazil, Oct. 2016, pp. 38–40.  
[doi:10.18429/JACoW-PCAPAC2016-WEPOPRP018](https://doi.org/10.18429/JACoW-PCAPAC2016-WEPOPRP018)
- [9] Angular, <https://angular.dev/>
- [10] Micronaut, <https://micronaut.io/>
- [11] D3, <https://d3js.org/>
- [12] P. Duval, R. Bacher, H. Ehrlichmann, D. Haupt, M. Lomperski, and J. Bobnar, “Automating Operation Statistics at PETRA-3”, in *Proc. 16th Int. Conf. Accel. Large Exp. Phys. Control Syst. (ICALEPCS'17)*, Barcelona, Spain, Oct. 2017, pp. 876–879.  
[doi:10.18429/JACoW-ICALEPCS2017-TUPHA189](https://doi.org/10.18429/JACoW-ICALEPCS2017-TUPHA189)