

Enhancing the Web-Based Interface for Mapping Liquid Argon Detector Components

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August 24, 2024

Abstract

This report outlines the enhancement of the LArIDTranslator, a web-based interface designed for mapping and visualizing data from the Liquid Argon (LAr) calorimeter within the ATLAS experiment at CERN. Building upon the foundational work of a previous intern, the current project focused on addressing usability challenges and implementing new features to improve the tool's functionality. Key enhancements include the creation of database tabs for different phases of the experiment, the introduction of dynamic URLs for easy data sharing, and the addition of a download feature allowing data export in various formats. Furthermore, the project involved refactoring the codebase to improve clarity and maintainability, as well as fixing critical bugs related to data filtering operations. The enhanced LArIDTranslator now offers a more robust and user-centric platform, significantly improving data management and collaboration among researchers in the ATLAS experiment.

Acknowledgments

The completion of this project has been made possible through the invaluable support and guidance of several key individuals and teams. Sincere appreciation is extended to my supervisor at CERN, whose mentorship has been a cornerstone of this journey. Their deep insights and unwavering encouragement have played a pivotal role in the successful execution of this project.

Profound gratitude is also owed to the ATLAS Liquid Argon team, whose collaboration and resource-sharing were instrumental in navigating the technical complexities encountered. Their generosity in sharing expertise and providing access to essential resources was critical in overcoming the various challenges faced.

Lastly, heartfelt thanks go to CERN for the opportunity to participate in this esteemed program. The chance to contribute to a project of such significance within a world-renowned institution has been both an honor and a deeply enriching experience, for which I am truly grateful.

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1 Introduction and Motivation

1.1 Overview of the ATLAS Liquid Argon Detector

The ATLAS experiment, located at the Large Hadron Collider (LHC) at CERN, is one of the largest and most complex particle physics experiments in the world. It plays a crucial role in advancing our understanding of fundamental particles and their interactions. Among its many components, the Liquid Argon (LAr) calorimeter stands as a vital element for detecting and measuring the energy of particles produced in high-energy collisions. The LAr calorimeter is integral to the accurate measurement of electromagnetic and hadronic particles, such as electrons and photons, which are essential for various physics analyses conducted within the ATLAS experiment.

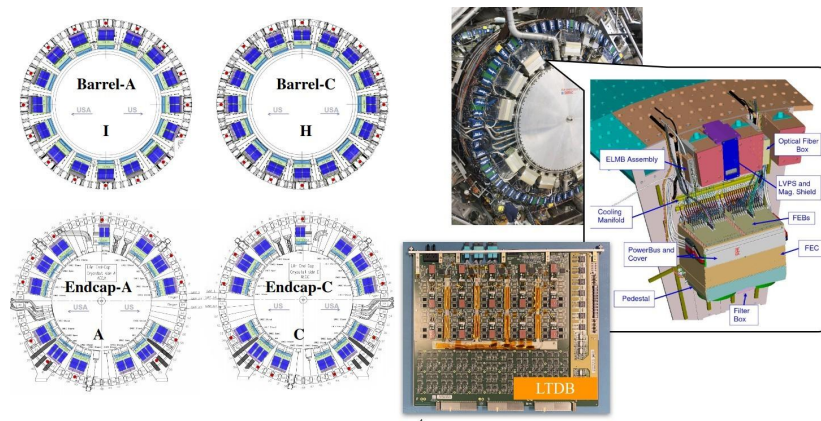


Figure 1: Front-End of the ATLAS Liquid Argon Detector

1.2 Background and Motivation for Enhancing the LArIDTranslator

In the summer of 2023, a previous intern initiated the development of the LArIDTranslator, a web-based tool designed to map and visualize data related to the LAr calorimeter within the ATLAS experiment. The tool provided a functional foundation for interacting with the LAr data, enabling easier access to critical information. However, feedback from the ATLAS LAr collaboration highlighted several areas for improvement, including enhanced data sharing capabilities, more intuitive navigation, and additional features such as data export.

Building upon the foundational work completed by the previous intern, the current project aimed to address these identified needs. The motivation for this enhancement project stemmed from the necessity to make the LArIDTranslator more robust, user-friendly, and capable of meeting the evolving requirements of the ATLAS experiment.

1.3 Project Objectives and Goals

The primary objectives of this project were to enhance the functionality and usability of the LArIDTranslator tool by addressing its limitations and expanding its capabilities. Specific goals included:

1. **Creating Additional Database Tabs:** To facilitate access to data from different phases of the ATLAS LAr detector, additional database tabs were introduced for Phase1, EMF, and Phase2 datasets.
2. **Implementing Dynamic URLs:** A dynamic URL feature was developed to allow users to share specific data queries and views more efficiently, enhancing collaboration within the research community.
3. **Introducing a Download Feature:** A download function was added, enabling users to export data in various formats (JSON, XML, CSV), thus improving the tool's versatility.
4. **Adding a Clear Filter Button:** To improve user experience, a clear filter button was incorporated, providing a straightforward way to reset filters and start new searches.
5. **Fixing the "Equal" Operation Bug:** Critical bugs, particularly those related to the "Equal" operation for integer fields, were addressed to ensure accurate data filtering.

By achieving these goals, the project aimed to create a more efficient and reliable tool that better supports the scientific community's data management needs within the ATLAS experiment.

2 Overview of Key Enhancements

This chapter outlines the major tasks undertaken during the enhancement of the LArIDTranslator tool. The focus was on improving functionality, usability, and code maintainability. Below is a summary of the key tasks along with a brief explanation of how each was implemented to achieve the project goals.

2.1 Task 1: Creating Tabs for Database Navigation

Objective: Introduce additional tabs to enable users to navigate between different phases of the ATLAS experiment datasets (Phase1, EMF, and Phase2).

Implementation:

- The tabs were created using the antd library's tab components. Each tab corresponds to a different database phase.
- A handler function was implemented to ensure the layout dynamically updates when switching between tabs, thereby maintaining the integrity of the data displayed.

This enhancement allowed users to seamlessly switch between datasets, improving workflow efficiency and data accessibility.

2.2 Task 2: Implementing Dynamic URLs

Objective: Enable users to share specific views or filtered data via dynamic URLs.

Implementation:

- React Router's `useLocation`, `useParams`, and `useSearchParams` hooks were utilized to capture the current state of the interface, including selected tabs, filters, and hidden columns.
- The dynamic URL was updated in real-time as users interacted with the tool, ensuring that shared links would recreate the exact data view when accessed by others.

This feature enhanced collaboration among researchers by making it easy to share specific data views, leading to more efficient data analysis.

2.3 Task 3: Adding a Download Button

Objective: Provide users with the ability to download filtered data in various formats (JSON, XML, CSV).

Implementation:

- A custom export menu was implemented, allowing users to select their preferred format.
- The download functionality was integrated into the user interface, respecting the current filters and selected columns to ensure that only the relevant data is exported.

The download feature streamlined the data export process, making it easier for users to analyze data outside the tool and ensuring compatibility with other data processing applications.

2.4 Task 4: Adding a Clear Filter Button

Objective: Improve user experience by providing a simple way to reset all filters applied to the data.

Implementation:

- A "Clear Filters" button was added to the user interface, allowing users to reset the filters with a single click.
- The button was linked to the filtering state of the data grid, ensuring that all active filters were cleared when the button was pressed.

This feature made the tool more user-friendly, allowing users to quickly start a new analysis without manually deselecting each filter.

2.5 Task 5: Refactoring and Fixing the "Equal" Operation

Objective: Address a bug in the "Equal" operation for integer fields, ensuring accurate data filtering.

Implementation:

- The code responsible for the "Equal" operation was reviewed and refactored to eliminate inefficiencies and ensure correct functionality.
- The logic for handling integer comparisons was corrected, and redundant code was removed to improve overall performance.

The refactored codebase is now more efficient and maintainable, and the "Equal" operation works as intended, providing accurate filtering for integer fields.

3 Summary of Implementation

The tasks outlined above were implemented using a combination of React, TypeScript, and MUI X DataGrid. By focusing on enhancing the tool's usability and functionality, the project successfully addressed the initial limitations and laid the groundwork for future improvements. The implementation was carried out with an emphasis on maintaining a clear and modular code structure, making it easier for future developers to build upon this work.

4 Application Demo

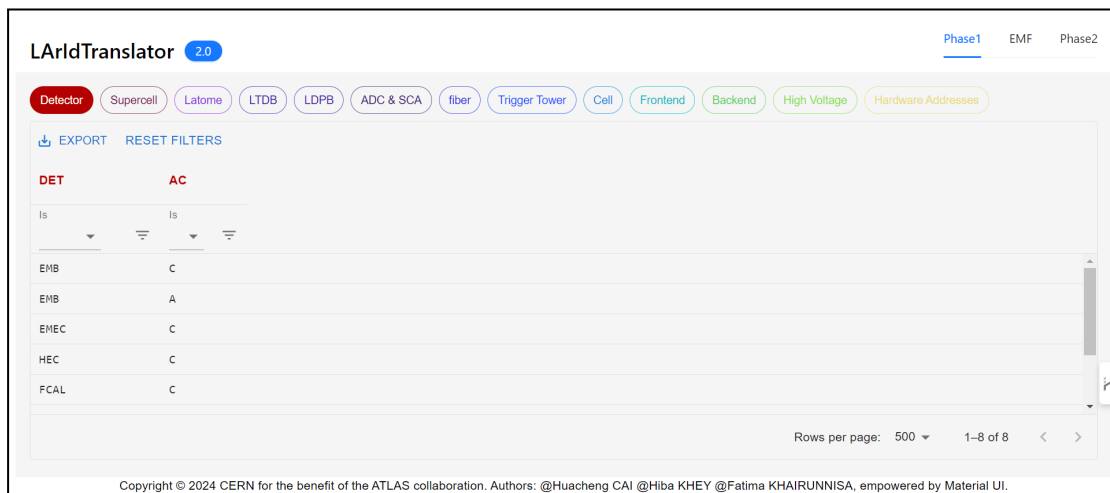


Figure 2: Front-End of the LArIdTranslator latest version

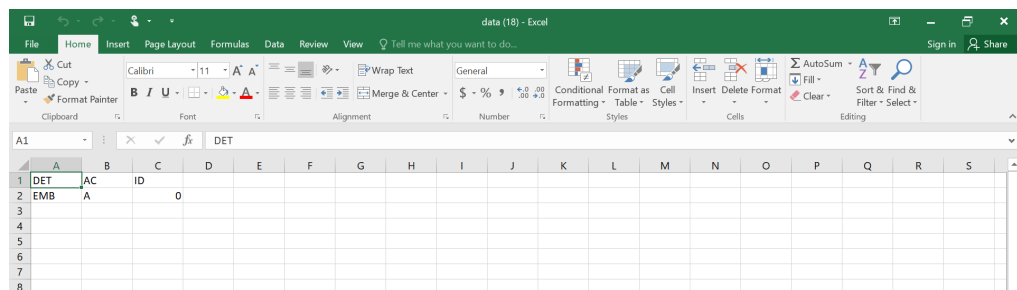
As shown in Figure 1, the application provides an intuitive user interface that allows users to filter and translate detector identifiers efficiently. The top of the interface displays several tabs that represent different phases of the detector configuration process. Below the tabs, a series of buttons such as "Detector," "Supercell," "Latome," and others allow users to quickly switch between different categories of detector components, with the URL dynamically updating based on the selected options.

The main content area displays a data grid that lists the detector components along with their corresponding attributes. Users can filter these components using the filter icons available in the column headers, which provides the ability to narrow down the data according to specific criteria.

Moreover, the interface features an "Export" button, which enables users to download the filtered data, and a "Reset Filters" button, which clears any applied filters to reset the data view. The application supports exporting data in various formats, including CSV, XML, and JSON, to ensure compatibility with different data processing tools. The following images illustrate the output for each format:

1. CSV Format:

The CSV export organizes the data into a tabular format with columns "DET," "AC," and "ID" as headers. Each row corresponds to a different detector component, as shown in the Excel file.

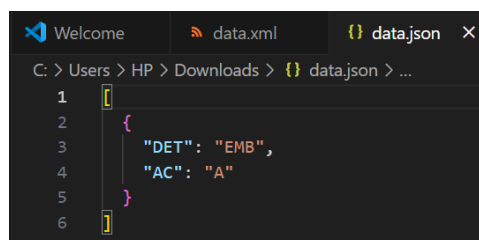


DET	AC	ID
EMB	A	0

Figure 3: Result in CSV format

2. JSON Format:

The JSON export structures the data in a key-value pair format, where each detector component's attributes are represented as key-value pairs, making it ideal for integration with web services or other JSON-based tools.



```

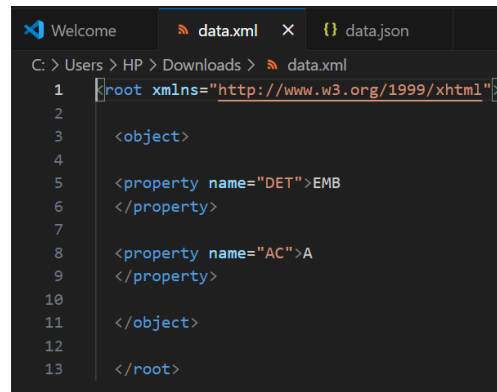
1  [
2    {
3      "DET": "EMB",
4      "AC": "A"
5    }
6  ]

```

Figure 4: Result in JSON format

3. XML Format:

The XML export presents the data in a structured markup format, with each component enclosed within tags, offering a hierarchical view that is suitable for data exchange in web applications.



```
1 <root xmlns="http://www.w3.org/1999/xhtml">
2
3   <object>
4
5     <property name="DET">EMB
6   </property>
7
8     <property name="AC">A
9   </property>
10
11 </object>
12
13 </root>
```

Figure 5: Result in XML format

These export options provide flexibility, allowing users to select the most appropriate format based on their specific needs.

5 Challenges and Solutions

5.1 Adapting to the Existing Codebase

The existing codebase was difficult to navigate due to its inconsistent structure and instances of "spaghetti code," particularly in areas like dynamic URL handling and tab-switching logic.

To address this, the code was refactored for better clarity and maintainability by breaking down complex functions into modular components. Comprehensive comments and documentation were added, and an incremental testing approach was implemented to ensure stability.

5.2 Learning and Implementing MUI X DataGrid Features

Implementing the advanced features of the MUI X DataGrid, such as dynamic URLs, filtering, and data export, posed a steep learning curve and integration challenges with the existing code.

Extensive study of documentation and examples was conducted, with features integrated step-by-step and thoroughly tested. Guidance from the supervisor and collaboration with other experts were essential in successfully implementing these features.

6 Results and Impact

The enhancements to the LARIDTranslator tool have delivered practical benefits:

- New features, such as navigation tabs and a clear filter button, have made the tool more user-friendly, allowing for smoother data analysis.
- The introduction of dynamic URLs has facilitated easier data sharing, fostering better teamwork among researchers.
- The ability to download data in various formats has expanded the tool's

utility, supporting diverse research needs.

These improvements have strengthened the tool's effectiveness within the ATLAS experiment, enabling more efficient research.

7 Conclusion and Reflection

The project successfully improved the LArIDTranslator tool, making it more user-friendly, efficient, and adaptable. These enhancements have strengthened its role in supporting research within the ATLAS experiment. The experience gained from overcoming challenges in coding and feature implementation has been invaluable for future projects.

8 Future Work

8.1 Suggestions for Further Enhancements

If the tool undergoes further development, it's important to monitor minor issues, particularly with the "Contains" and "Equal" filtering in the columns. These bugs, though minor, could impact other well-functioning parts of the code if changes are made.

8.2 Alignment with Long-Term Goals of the ATLAS Experiment

The long-term goal for the tool is to fully integrate the Phase2 and EMF databases, making the tool even more comprehensive and aligned with the evolving needs of the ATLAS experiment.

9 References

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