Optimizing the Way We Interact with Scientific Data: The Dust Data Digger Application

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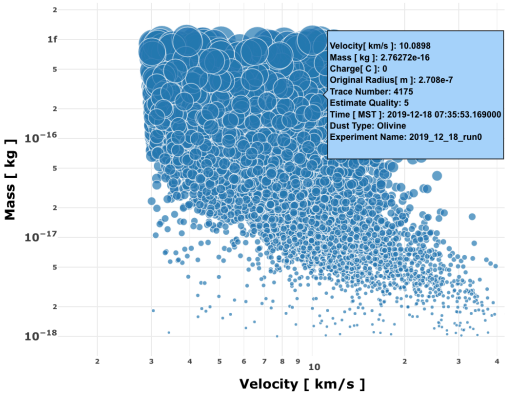
In scientific research, being able to quickly access and visualize data is crucial. This work will discuss the Dust Data Digger, a full-stack web application designed to revolutionize how scientists interact with data from the Pelletron Accelerator at the Institute for Modeling Plasma, Atmospheres, and Cosmic Dust (IMPACT) within the Laboratory for Atmospheric and Space Physics (LASP). The IMPACT lab hosts a 3 MV linear electrostatic dust accelerator, which is used for calibrating dust flight instruments. Historically, accessing this data required SQL queries and a single-instance LabVIEW software, limiting accessibility and efficiency for the user.

The Dust Data Digger was developed to address these limitations by providing an intuitive web-based interface accessible via both the IMPACT website https://impact.colorado.edu/ and an installable desktop version. Both versions require LASP VPN access, ensuring secure and remote data availability. This application enhances accessibility by allowing users from any computer with access to the LASP VPN to interact with the data .

The application offers controls to set constraints on the data, such as the number of data instances, experiment group, experiment name, dust type (composition), velocity, mass, charge, radius, estimate quality, and the date-time of the dust shot.

Upon submission, the data is presented in two formats: an interactive plot and a exportable .csv table of the plotted data.

The interactive plot allows users to customize the x and y axis by selecting one of the options; velocity, mass, time (date-time), charge, radius, trace number, and estimate quality. Users can choose between logarithmic or linear scales for each axis. Each data point's radius is scaled to reflect the actual size, and hovering over a point displays detailed information for that point. For further analysis, this interactive plot can be saved as a .png file.



The data table provides a customizable view of the data, with options to select which columns are included, sort the data by different columns, and sort the data in either descending or ascending order. There is also a clickable button to download the table as a .CSV file. This flexibility ensures

that users can tailor the data presentation to their specific needs.

The Dust Data Digger is built using modern architecture. The backend, which was developed by using Python and SQLAlchemy, connects to the data server and processes SQL queries based on API calls from the React-based frontend. Flask APIs handle these requests, ensuring efficient data retrieval and processing. The frontend, built with React and TypeScript, leverages the Plotly library for plotting and the MUI library for styling and table management. The desktop version is built with Electron to provide a seamless user experience across different platforms.

The Dust Data Digger demonstrates how modern software can optimize scientific workflows, enhancing data accessibility and usability. By transitioning from a restrictive, single-computer setup to a versatile web-based solution, the application empowers scientists to perform more efficient and comprehensive data analysis, driving research forward.

In conclusion, the Dust Data Digger not only simplifies data access but also provides powerful tools for visualization and analysis, demonstrating the potential of modern full-stack applications to aid in scientific research.