

Open Source Software to Accelerate the Development of Energy Storage Systems

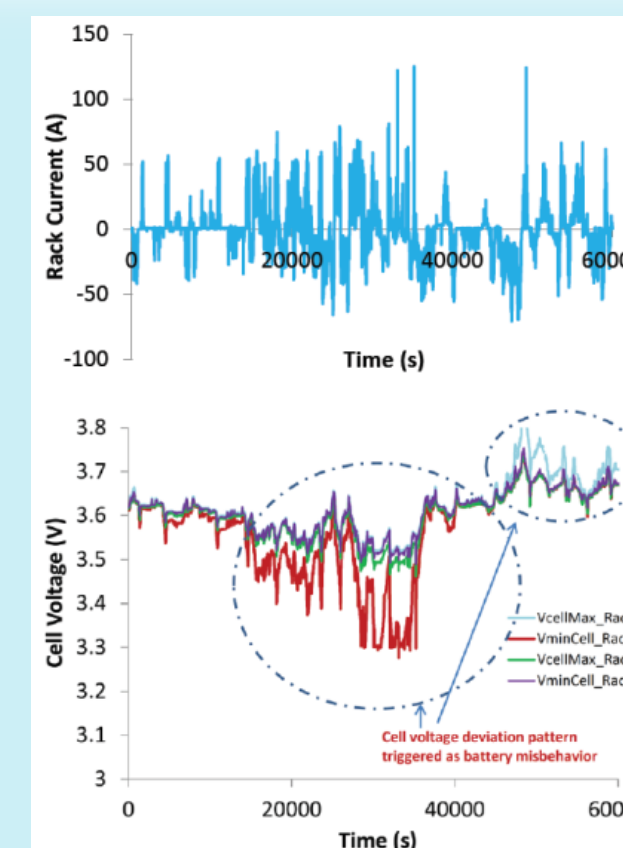
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CHALLENGES IN THE ENERGY STORAGE INDUSTRY

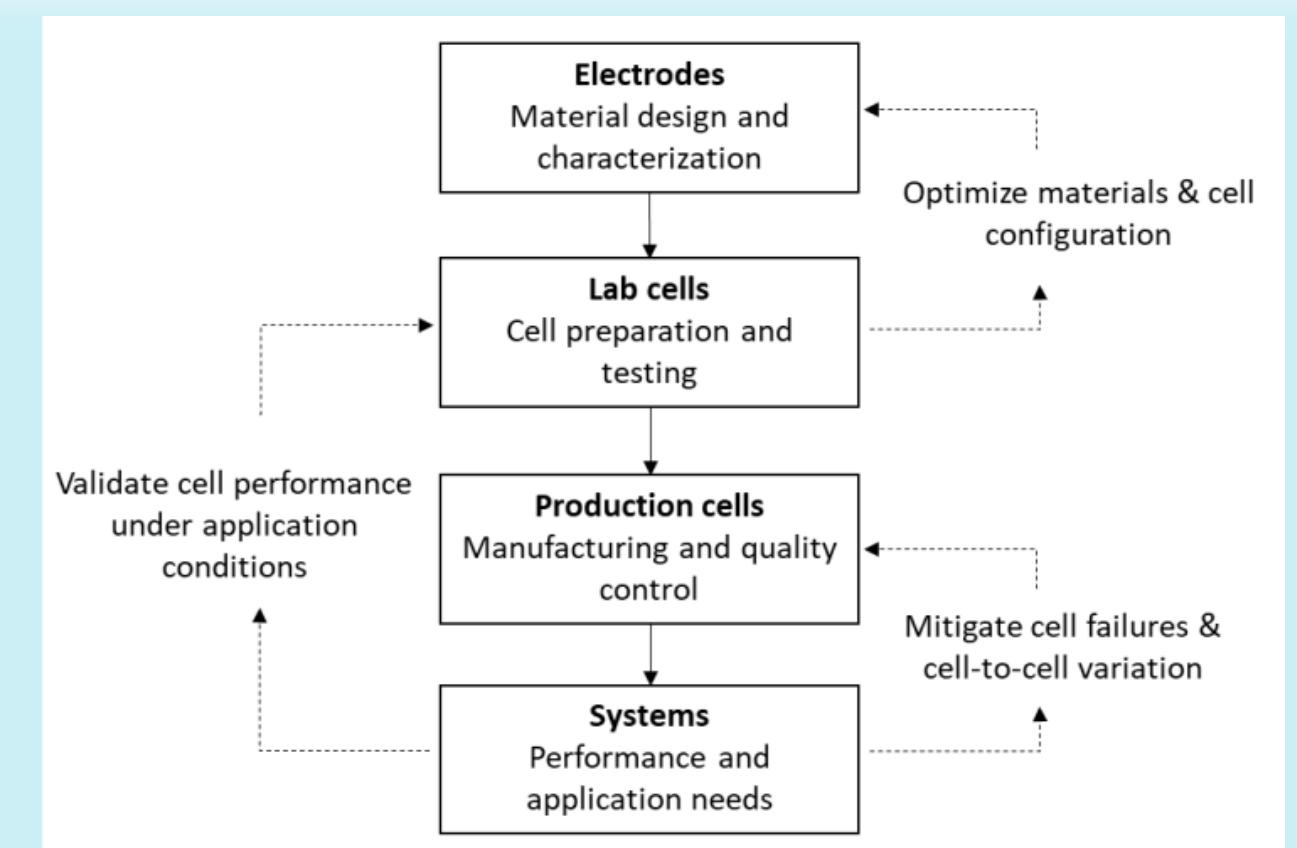
- Technologies that show promise in lab prototypes struggle to scale and reach the performance needed for commercial products
- System designs are not standard, so integration and maintenance costs are high
- Failure of a single module can lead to catastrophic system failures

Opportunities with Open Source Packages

- Leverage existing resources from the community instead of redeveloping tools
- Modify and extend a package as needed for desired use cases
- Easily integrate with other software and hardware resources



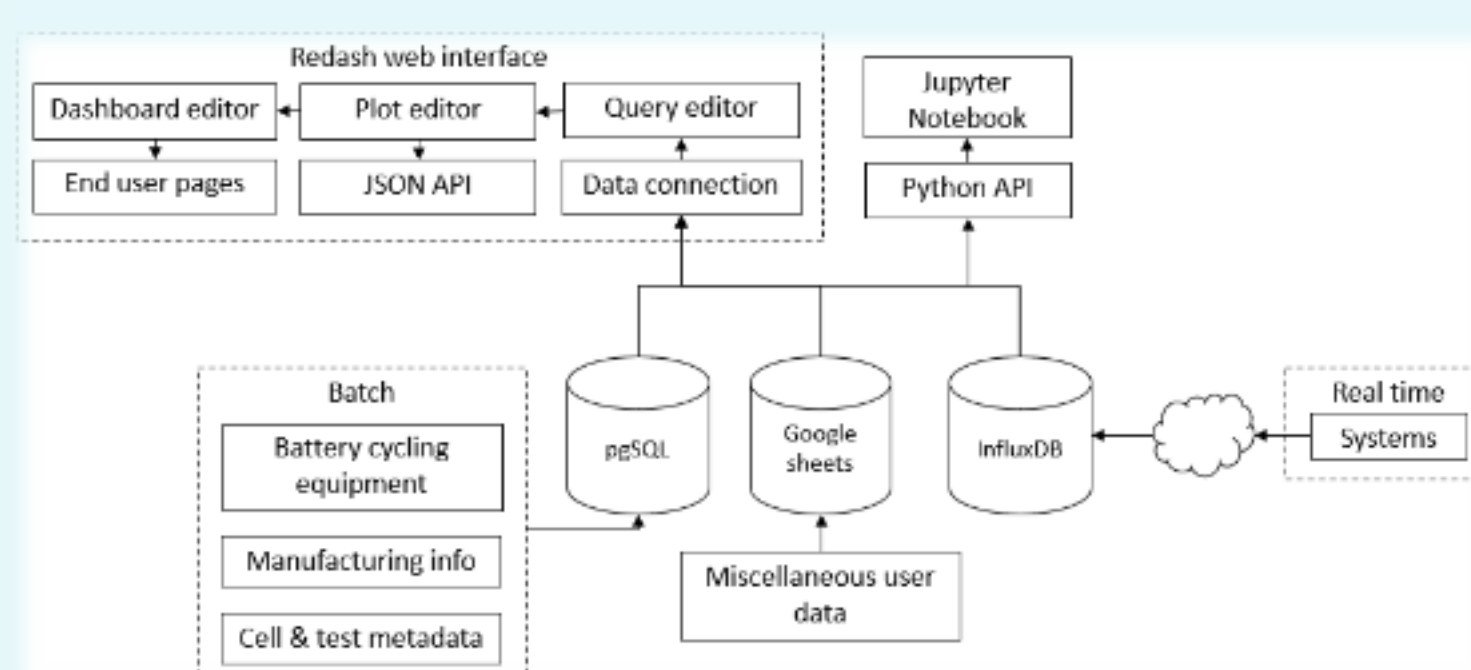
Commercial products can degrade in unexpected ways



Integrating data across the battery lifecycle can be used to predict system failures

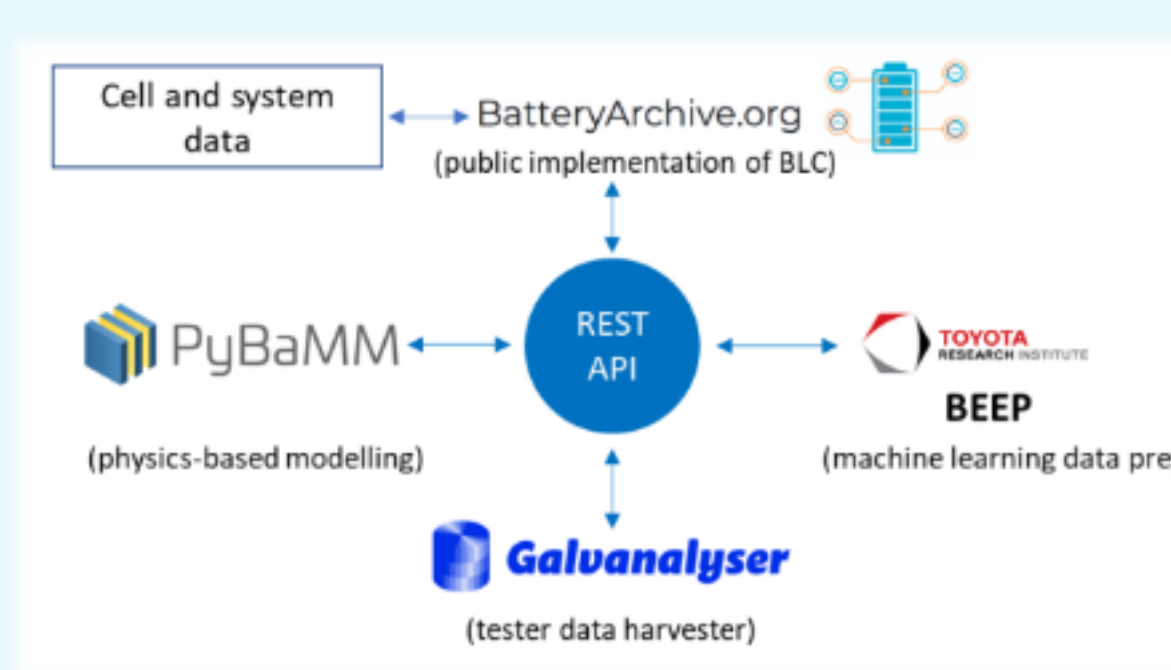
SOFTWARE DEVELOPMENT APPROACH

Battery Lifecycle Framework



Representative model (system architecture is not tied to a single database schema or visualization tool)

Software Ecosystem: link tools using compatible APIs

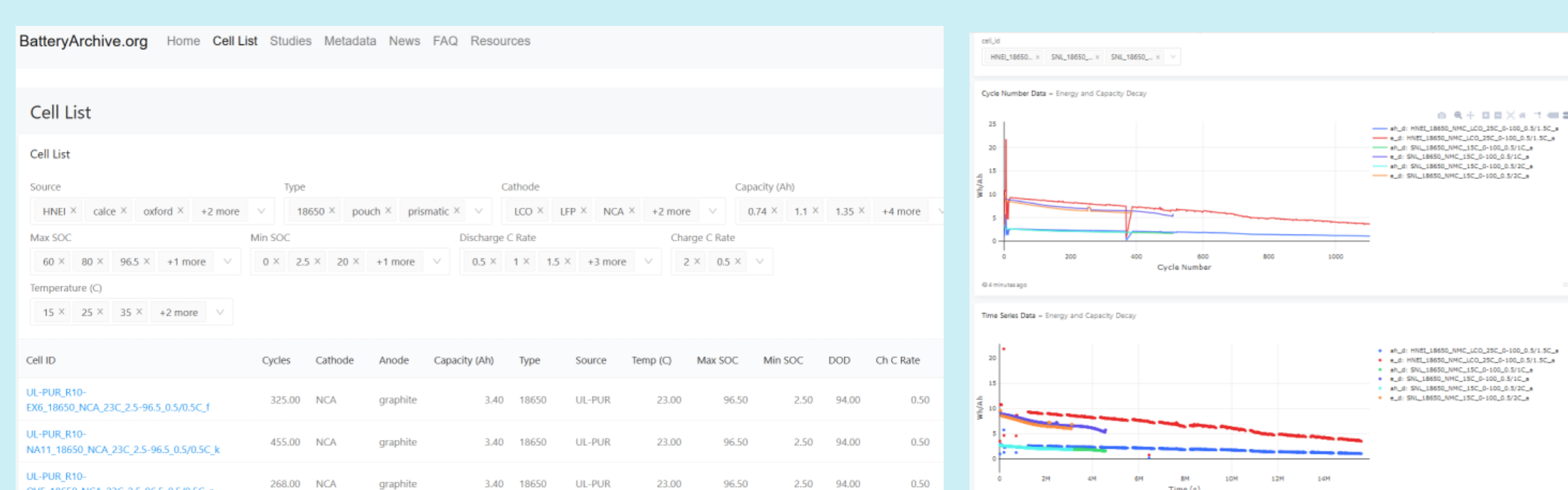


Example integration between existing battery data tools

- Battery Lifecycle Framework (BLC) is an open-source platform that provides tools to visualize, analyze, and share battery data through the technology development cycle
- BLC has four components: (1) data importers, (2) one or more databases, (3) a front-end for querying the data and creating visualizations, (4) an application programming interface to process the data and enable integration with other software resources
- BLC will also include standardized power electronics and control software for the operation of hybrid battery packs

SOFTWARE IMPLEMENTATION WITH DIFFERENT USERS AND DATA TYPES

Visualize public battery cycling data

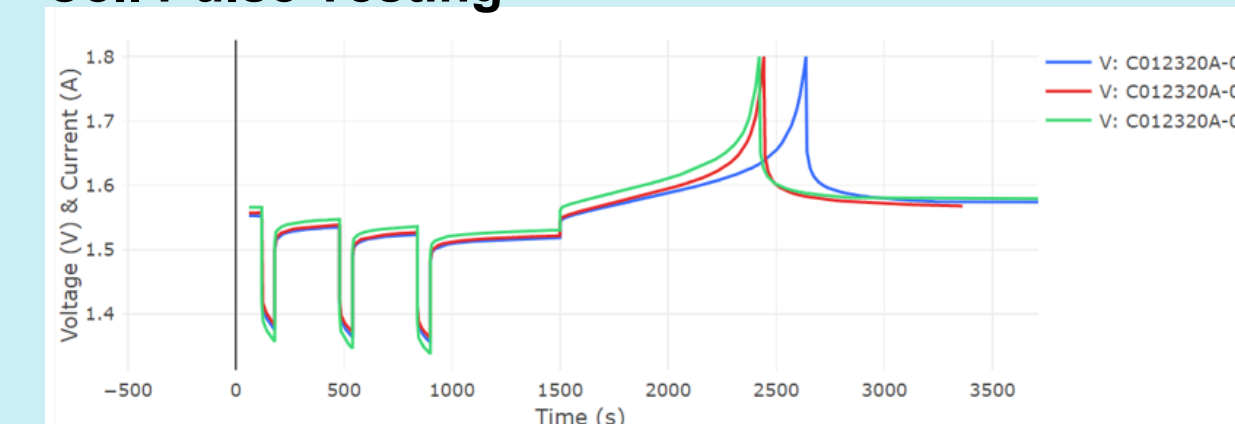


Importing battery cycling data from different sources into a common format facilitates comparison across institutions

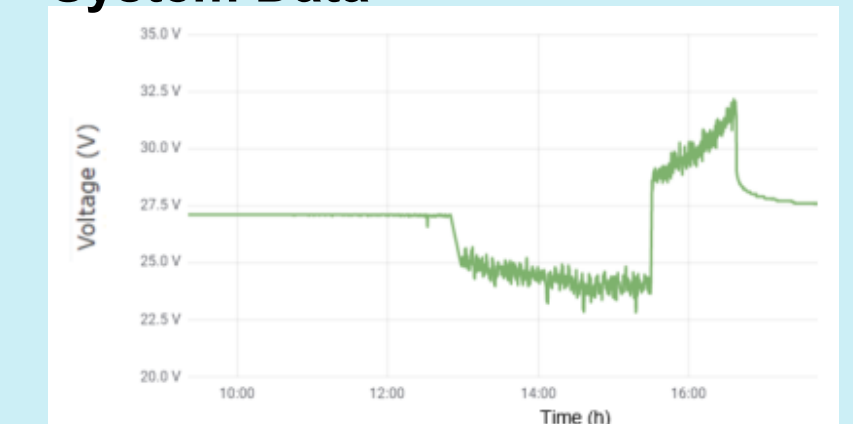
Consolidate data from manufacturing to systems

Production Data	cell_id	study	Anode Batch ID	Cathode Batch ID	Anode Weight (kg)	Cathode Weight (kg)
	C012320A-038	3-pulse+1-cycle-Battery 1-SBT	A - 011520	C - 110819	0.98	1.80
	C012320A-041	3-pulse+1-cycle-Battery 1-SBT	A - 011520	C - 110819	0.98	1.80
	C012320A-045	3-pulse+1-cycle-Battery 1-SBT	A - 012120	C - 110819	0.96	1.86

Cell Pulse Testing

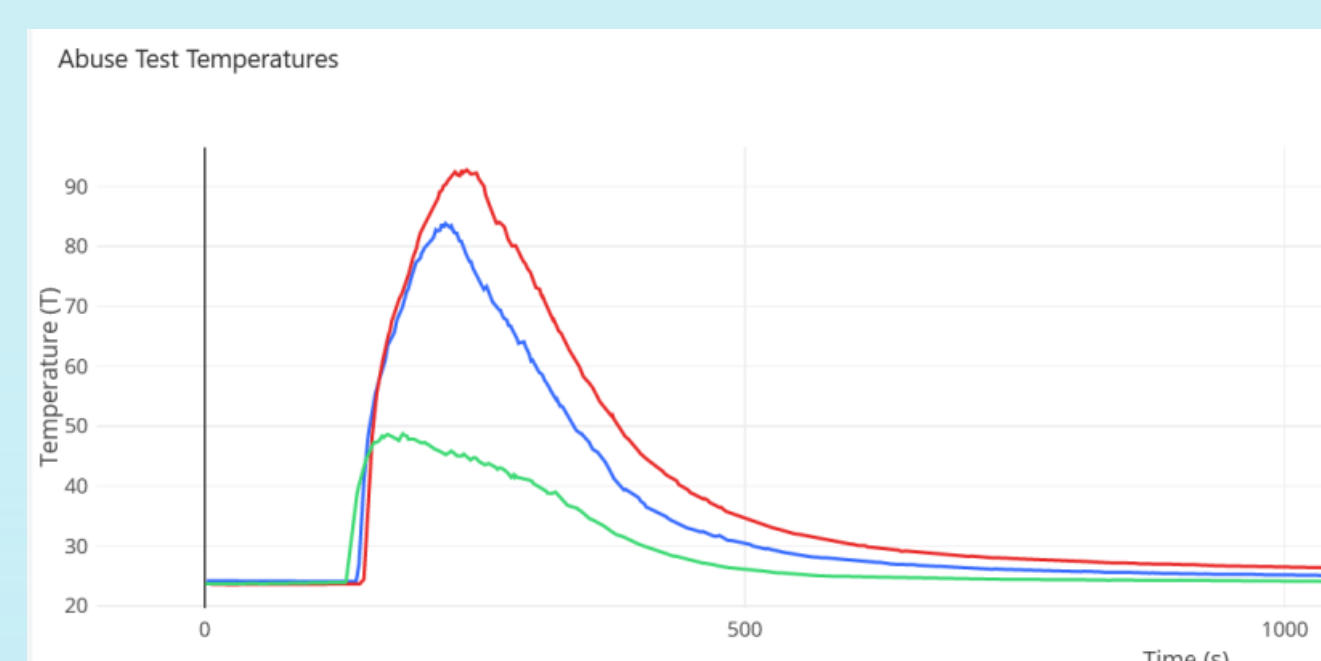
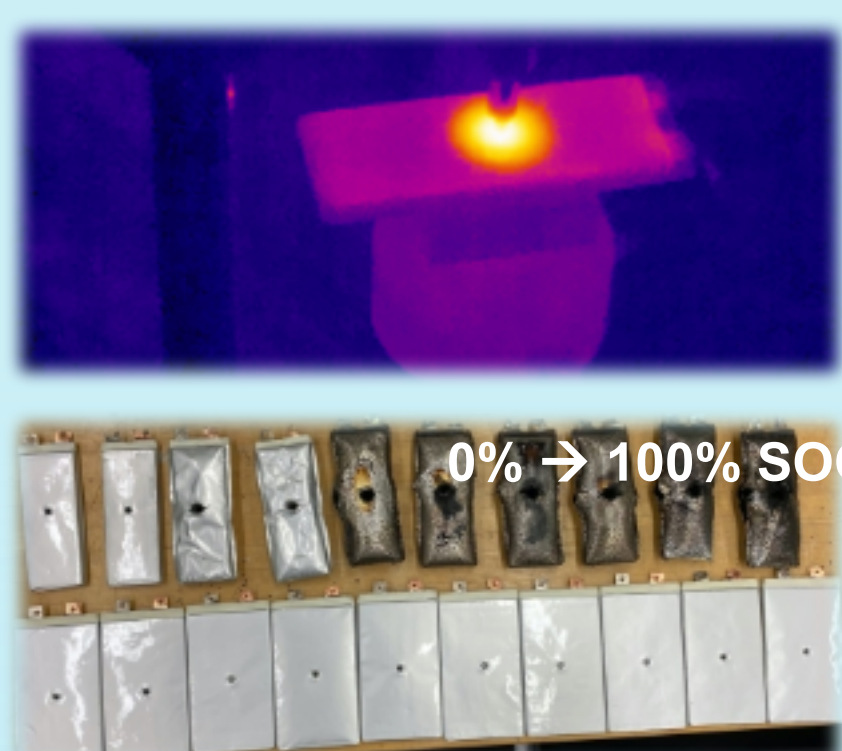


System Data



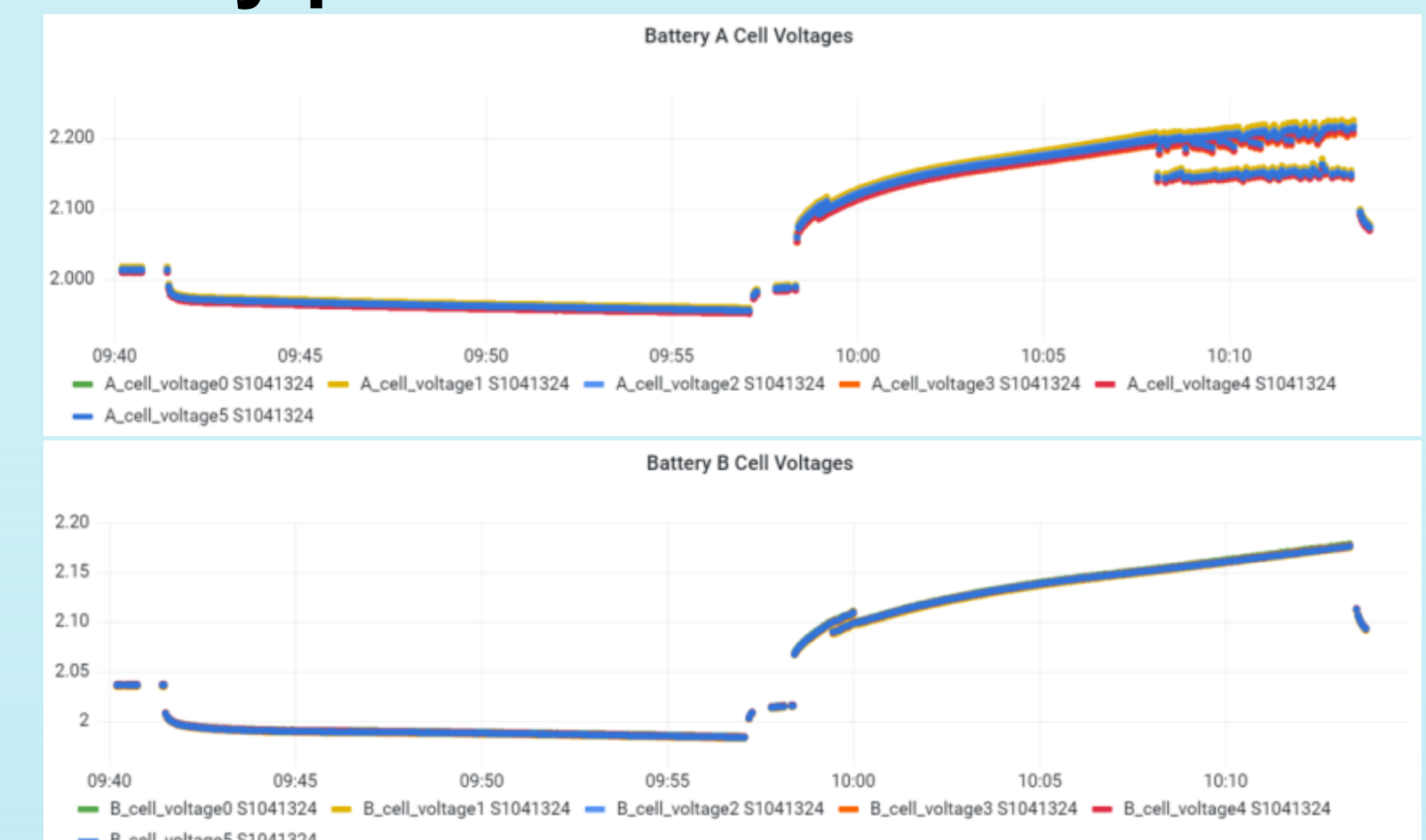
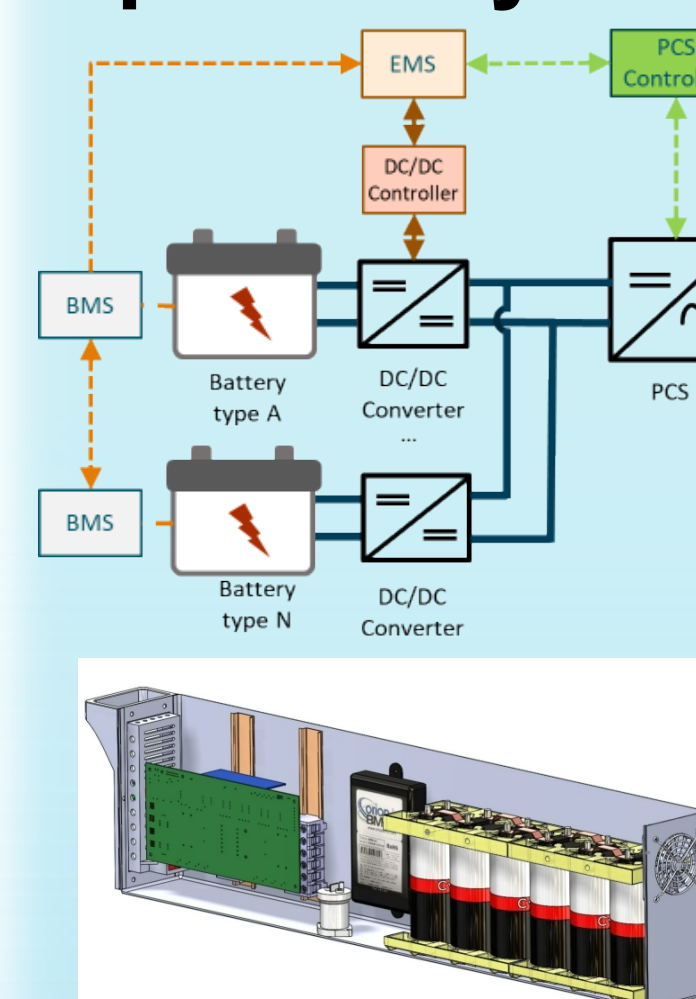
Linking different types of data across the battery lifecycle enables optimization of materials and cell configurations

Incorporate thermal runaway risk prediction



Aggregating data from a single standard protocol for battery abuse enables prediction of thermal runaway risks for new cells

Operate hybrid battery packs and centralize data



Open source power electronics, modules, and control software

References: Public site: www.BatteryArchive.org
Github: <https://github.com/battery-lcf>
Technical publication: <https://ecsarxiv.org/h7c24>

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We would like to thank the DOE Energy Storage Program and Dr. Imre Gyuk for generous financial support of this project.