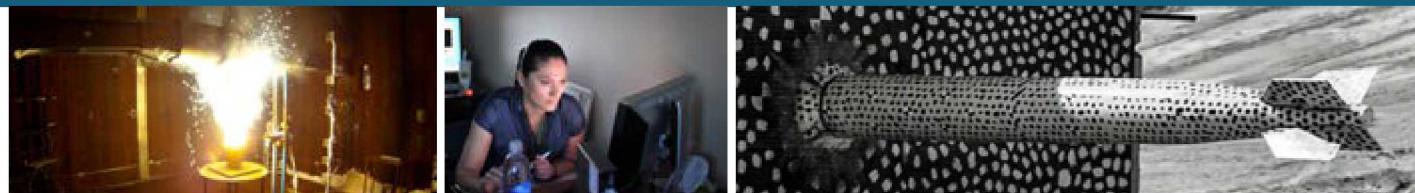


# Safety and Performance of Commercial Li-Ion Cells



*PRESENTED BY*

Yuliya Preger

DOE OE Peer Review 2019

September 25, 2019



Sandia National Laboratories is a multimission laboratory managed and operated by National Technology & Engineering Solutions of Sandia, LLC, a wholly owned subsidiary of Honeywell International Inc., for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA0003525.

SUMMARY: Experimentally quantify commercial Li-ion battery failure at the cell and materials level

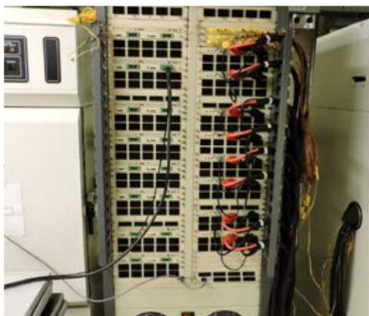
#### SIGNIFICANCE:

- Li-ion battery energy storage system selection is fraught with uncertainty
  - Limited performance and safety data is available from manufacturers, making it difficult to quantify risk at various operating conditions
- Broader understanding of degradation and failure can inform new technologies for intervention

#### ALIGNMENT WITH CORE MISSION OF DOE OE:

- Energy storage systems contribute to resilience, reliability, and flexibility of energy infrastructure
- Dissemination of ‘apples to apples’ safety and performance data can accelerate risk assessment, selection, and adoption of energy storage technologies

### Sandia Battery Test Facilities



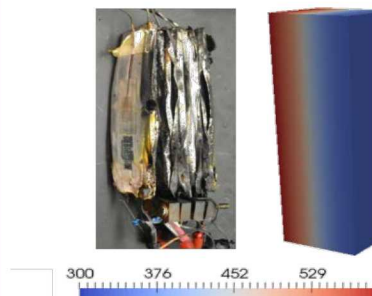
Summer Ferreira  
Yuliya Preger  
Armando Fresquez  
Heather Barkholtz  
(former SNL)

### Sandia Battery Abuse Lab



Loraine Torres-Castro  
Joshua Lamb  
Jill Langendorf

### Sandia Fire Sciences

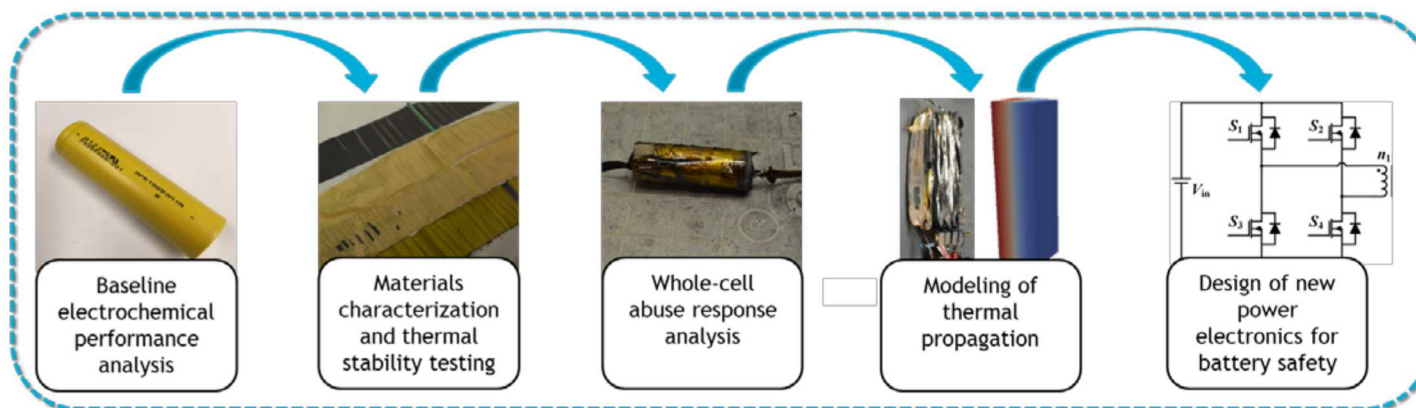


John Hewson  
Randy Shurtz  
Andrew Kurzawski

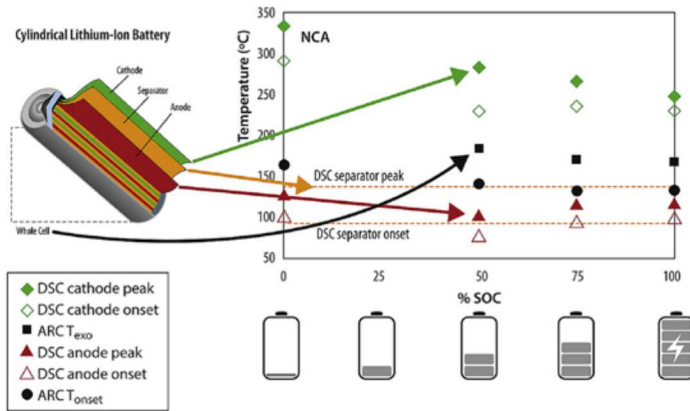
### Center for Integrated Nanotechnologies



Sergei Ivanov

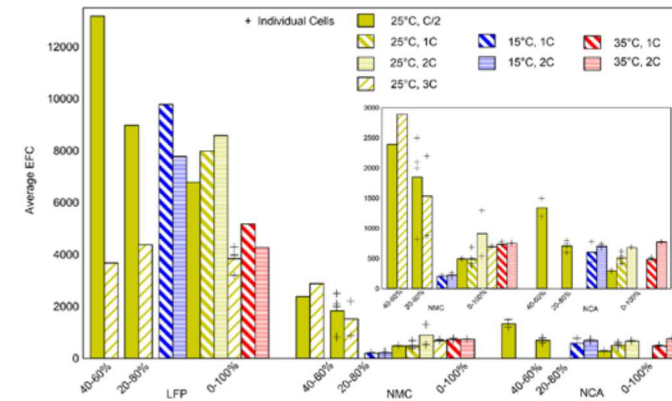


## Safety



- Relate component to whole cell failure for popular commercial Li-ion chemistries
- Compare failure response from fully charged to fully discharged state

## Performance



- Understand difference in aging behavior as a function of chemistry, environment, and use case for popular commercial Li-ion chemistries
- Relate fading performance to change in core electrochemical/materials properties





	Milestone	Current Status
Safety	<ul style="list-style-type: none"><li>• Whole cell calorimetry for LCO, LFP, NCA at 0, 50, 75, and 100% SOC</li><li>• Calorimetry of separator, anode, and cathode components at 0, 50, 75, and 100% SOC</li></ul>	<ul style="list-style-type: none"><li>• Full study completed and published</li><li>• All data posted on safety website<sup>1</sup></li></ul>
Performance	<ul style="list-style-type: none"><li>• Complete cycling of LFP, NCA, NMC cells to 80% capacity</li><li>• Complete calendar aging of LFP, NCA, NMC to 80% capacity</li></ul>	<ul style="list-style-type: none"><li>• NCA/NMC cycling complete; most LFPs still in progress</li><li>• First publication on long-term cycling performance about to be submitted</li></ul>

<sup>1</sup><https://www.sandia.gov/energystoragesafety-ssl/>



## Challenge

## Outcome

### Safety

- No standard procedure for battery and component calorimetry
- Slight differences in sample prep can lead to substantial difference in heat release

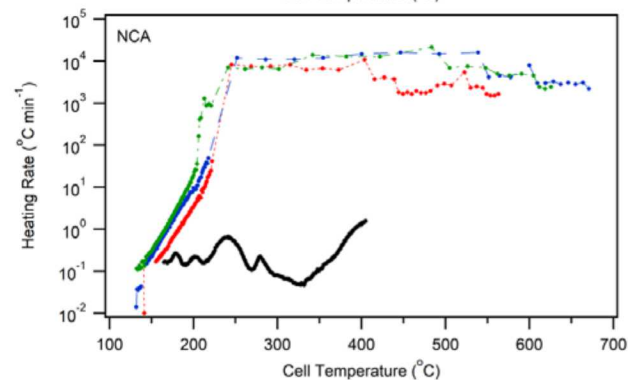
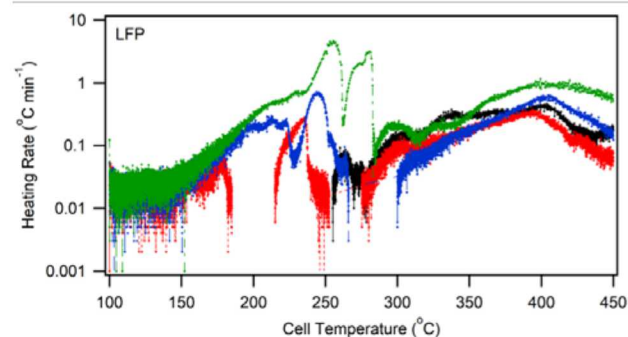
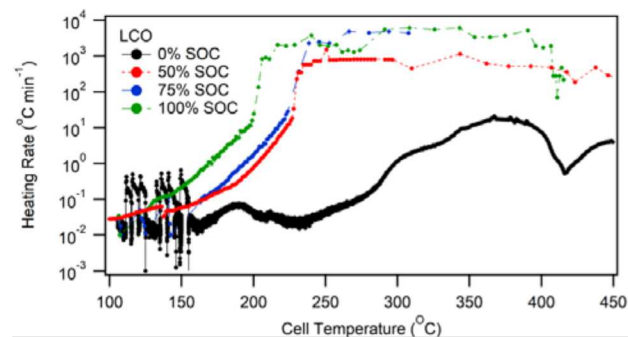
- Published perspective on best practices in battery calorimetry
- Organized workshop on battery calorimetry at Electrochemical Society Meeting [part of ongoing collaborative group]

### Performance

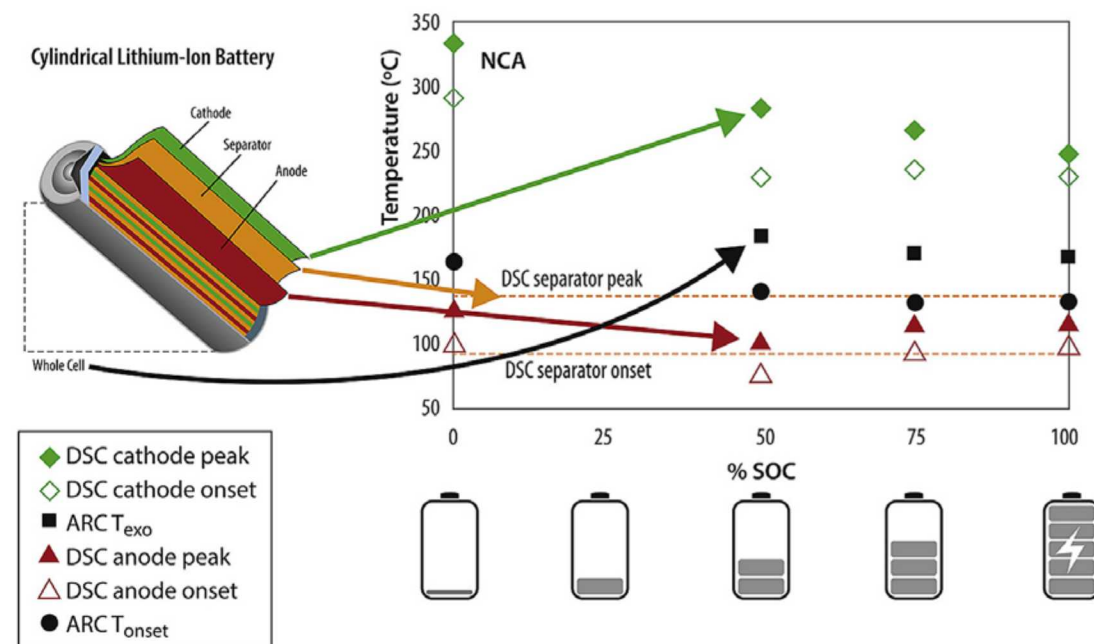
- Difficult to compare consistency of data across studies; results only available in graphical form

- New collaboration with Dr. Venkat Subramanian (UT-Austin) to develop publicly accessible battery data repository + analytics tool

## Thermal runaway measurements for commercial Li-ion batteries at multiple SOC



## Component level degradation onset mapped to whole cell runaway



Barkholtz et al. *J. Power Sources* **2019**, 435, 226777.

Shurtz et al. *J. Electrochem. Soc.* **2019**, 166, 12, A2498-A2502.

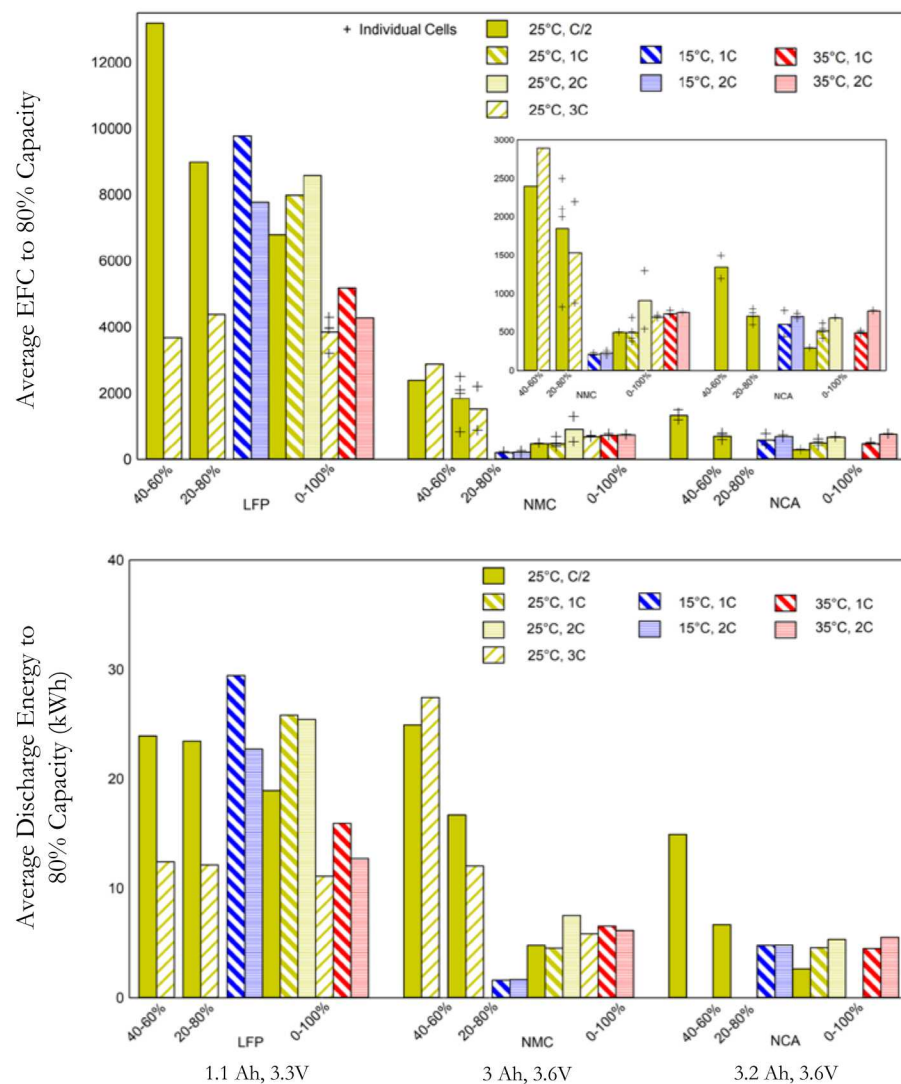
Calorimetry collaborative meeting at 2019 Electrochemical Society (ECS) Spring Meeting

Presentations at: 2019 ECS Spring Meeting

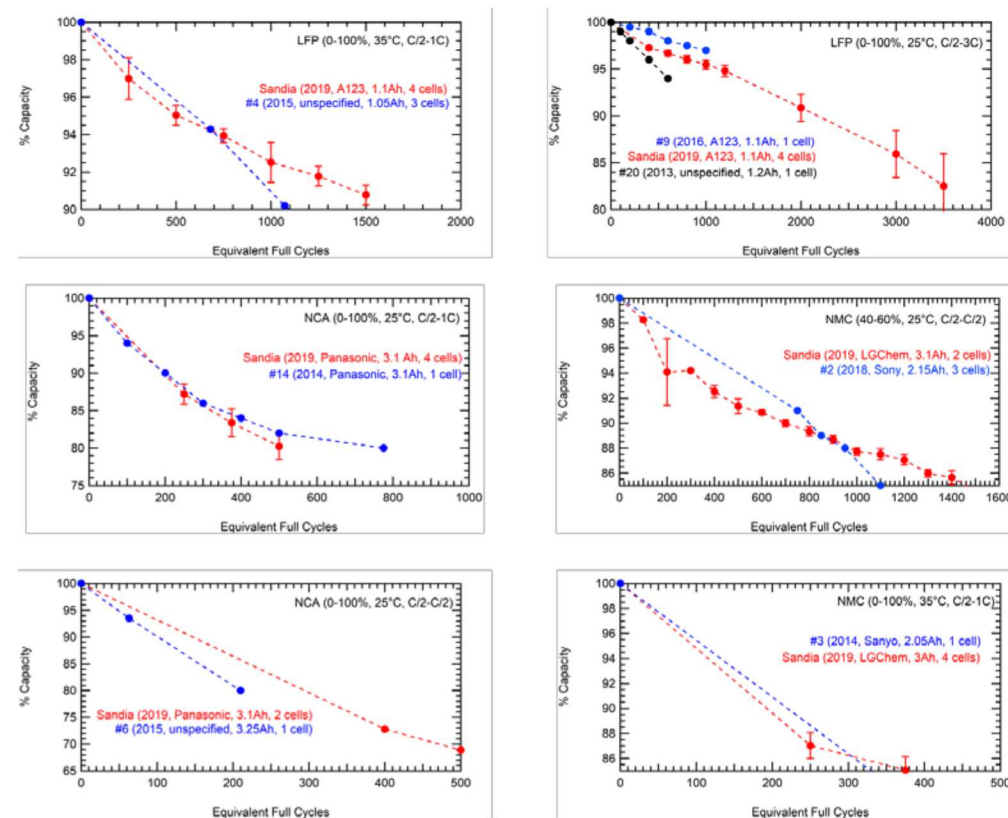
For more details, see poster: *Multi-scale Thermal Stability Study of Lithium-ion Batteries as a Function of Chemistry and State of Charge*



Broadest head-to-head comparison among different cell types in open literature



Comparison to previous studies to identify broad trends vs. consistent numbers

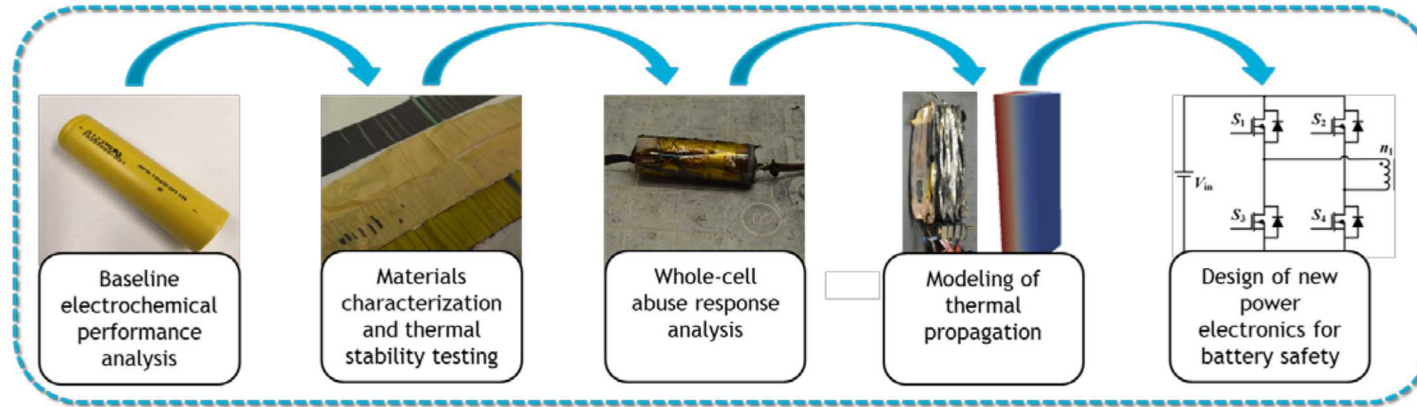


Manuscript to be submitted

Presentations at: Battery Safety Conference, Energy Storage Safety & Reliability Forum, 2019 ECS Spring Meeting

For more details, see poster: *Durability and Reliability of Commercial Lithium-Ion Cells as a Function of Chemistry and Cycling Conditions*





## Performance

- Continue LFP cycling and calendar aging to 80% capacity
- Identify tipping points in performance when cycling beyond 80% capacity
- Develop public battery data repository

## Lithium-Ion Battery Calorimetry Workshops (task for full safety team)

- Set up website for sharing and modeling thermal runaway data
- Schedule next workshop, continue recruiting participants

## Power Electronics & Safety

- Determine influence of module configuration and power electronics topology on degradation
- Investigate possible interventions in imminent battery failure scenarios

## PROJECT CONTACTS



- Funded by the U.S. Department of Energy, Office of Electricity, Energy Storage program. Dr. Imre Gyuk, Program Director.
- Sandia National Laboratories is a multi-mission laboratory managed and operated by National Technology and Engineering Solutions of Sandia, LLC., a wholly owned subsidiary of Honeywell International, Inc., for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA-0003525.
- This work was performed, in part, at the Center for Integrated Nanotechnologies, an Office of Science User Facility operated for the U.S. Department of Energy (DOE) Office of Science by Los Alamos National Laboratory (Contract DE-AC52-06NA25396) and Sandia National Laboratories (Contract DE-AC04-94AL85000).

For questions about this presentation: [ypreger@sandia.gov](mailto:ypreger@sandia.gov)

For further details on experimental work, see the following posters:

- **Safety:** Multi-scale Thermal Stability Study of Lithium-ion Batteries as a Function of Chemistry and State of Charge
- **Performance:** Durability and Reliability of Commercial Lithium-Ion Cells as a Function of Chemistry and Cycling Conditions



## Publications

- Barkholtz et al. *J. Power Sources* **2019**, 435, 226777.
- Shurtz et al. *J. Electrochem. Soc.* **2019**, 166, 12, A2498-A2502.
- Preger et al. “Durability and Reliability of Commercial Lithium-Ion Cells as a Function of Chemistry and Cycling Conditions” Manuscript to be submitted.

## Presentations

- 2018 Battery Safety Conference
- 2019 Energy Storage Safety & Reliability Forum
- 2019 Electrochemical Society Spring Meeting [two talks]
- 2019 California Energy Commission Energy Storage Workshop [two talks]

## Other

- Li-ion battery calorimetry workshops
- Collaboration with Dr. Venkat Subramanian on public battery data repository and analytics tool