Triggering Thermal Runaway in Lithium Ion Cells using Laser Radiation - Latest Findings

By

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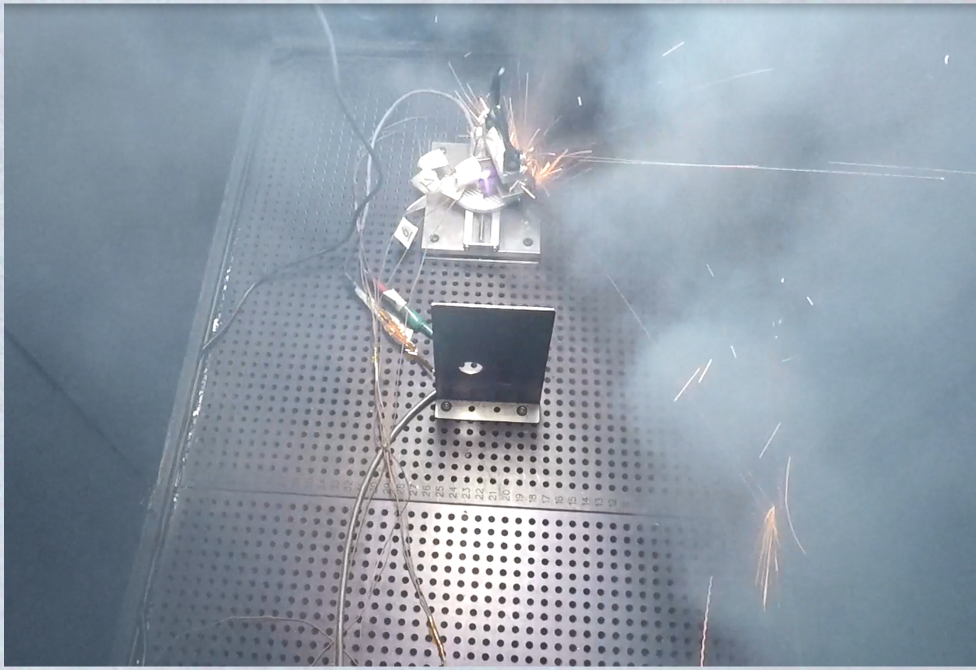
Agenda

- Intro – Why Laser
- Operating Principle
- Video – 50W laser run
- FY19 Objective
- Test Method
- Test Hardware
- Results
- Lessons Learned
- Future Work

Intro – Why Laser

- Laser initiation offers a new way to induce thermal runaway via heating, and has compelling advantages over traditional patch or other contact heaters.
  - Contactless, lower bias to results
  - Highly repeatable energy input
  - No hand labor to create heaters
  - Less modification to battery bricks to include trigger
  - Able to travel through fiber cables into sealed enclosures
  - Extremely high flux capability



Operating Principle

- A beam-absorbing coating is put onto the cell can that transfers incident beam energy into and through the cell can wall, locally heating outer wind of electrode and separator, creating a local short.
- High flux allows beam energy to overcome losses due to conduction away from target through the cell can, convective losses to circulating electrolyte.
- If the correct flux is determined, wattage can be dropped as low as possible in order to reduce total energy into the cell, producing a more realistic thermal runaway.
- Less input power means less overall temperature, allowing the cell can to remain strong, causing failure mode to closely resemble field failure.

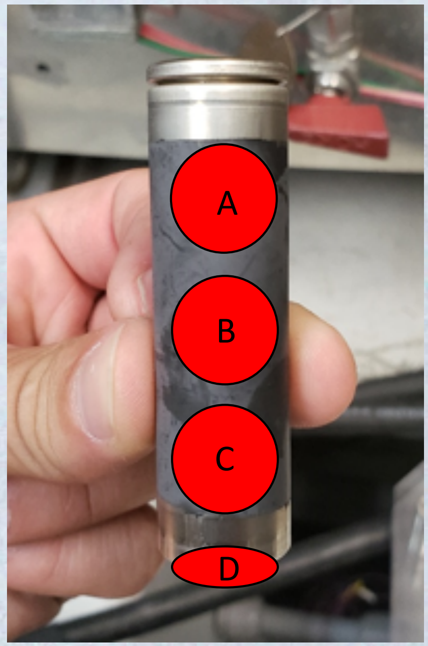
Video - 50 W Laser Run 1 – 6 Second TR

FY19 Objective

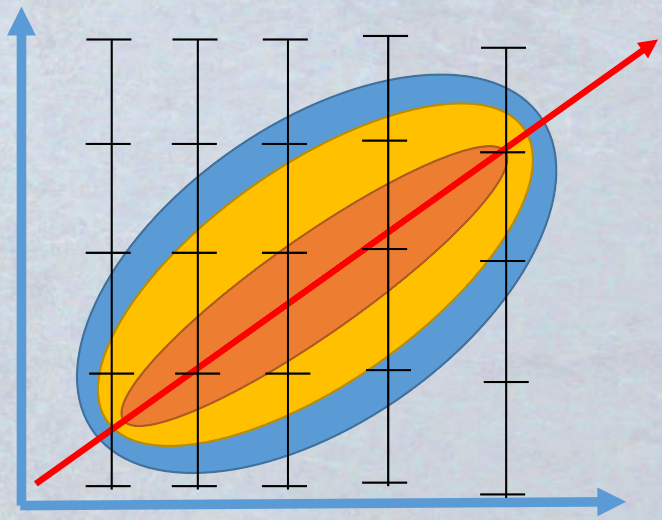
- This work has been ongoing for a few years now.
- New, highly repeatable test rig to improve test rigor
- Very high throughput to give statistical significance to data
- First effort to determine Ideal flux curve and “regions of increasing stability”

Test Method

- For the scope of our initial assessment, we keep static:
  - Cell size, model, and chemistry
  - Cell can material
  - Thermal losses
  - Can orientation
  - Coating type
- We vary:
  - Beam Target Area
  - Beam Wattage
  - Beam Target Location
- We determine:
  - Regions of increasing stability
  - Ideal flux curve



Ideal Flux Curve Determination

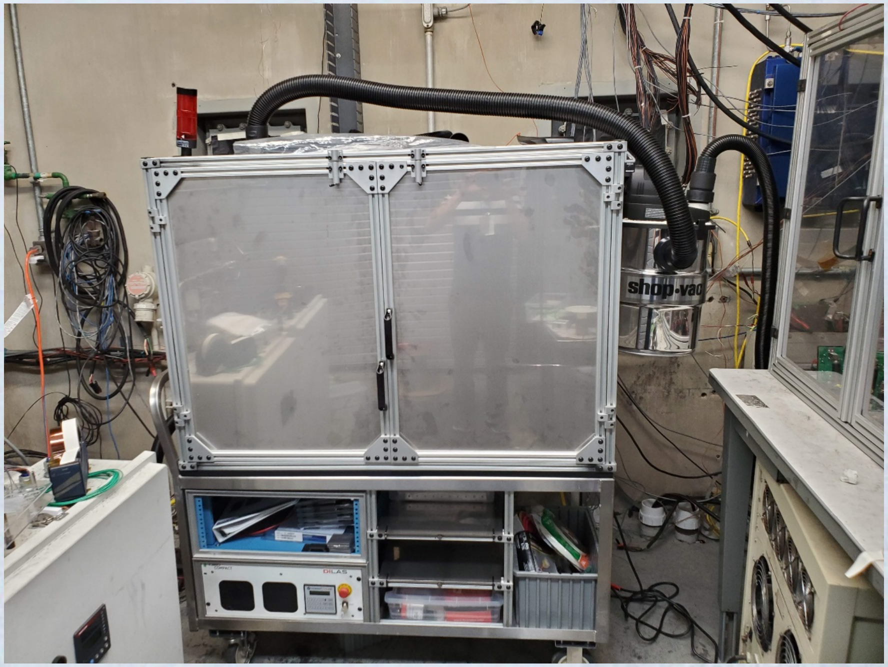


Select a cell type, coating, and target location

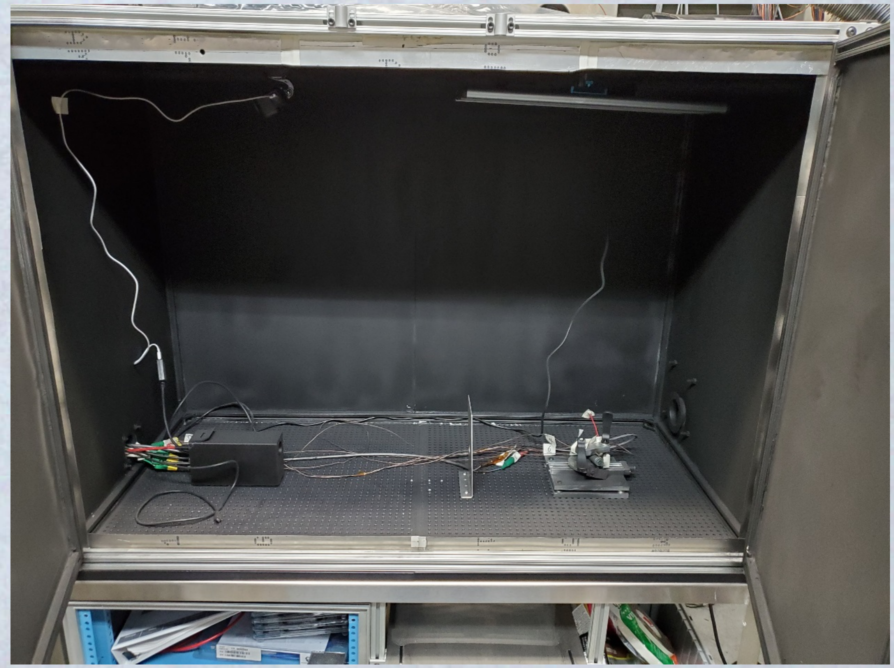
Maintain an area, and run from low to high wattage to determine upper and lower bounds for each region before moving to next area.

Test Hardware 1

Test Stand Exterior



Test Stand Interior

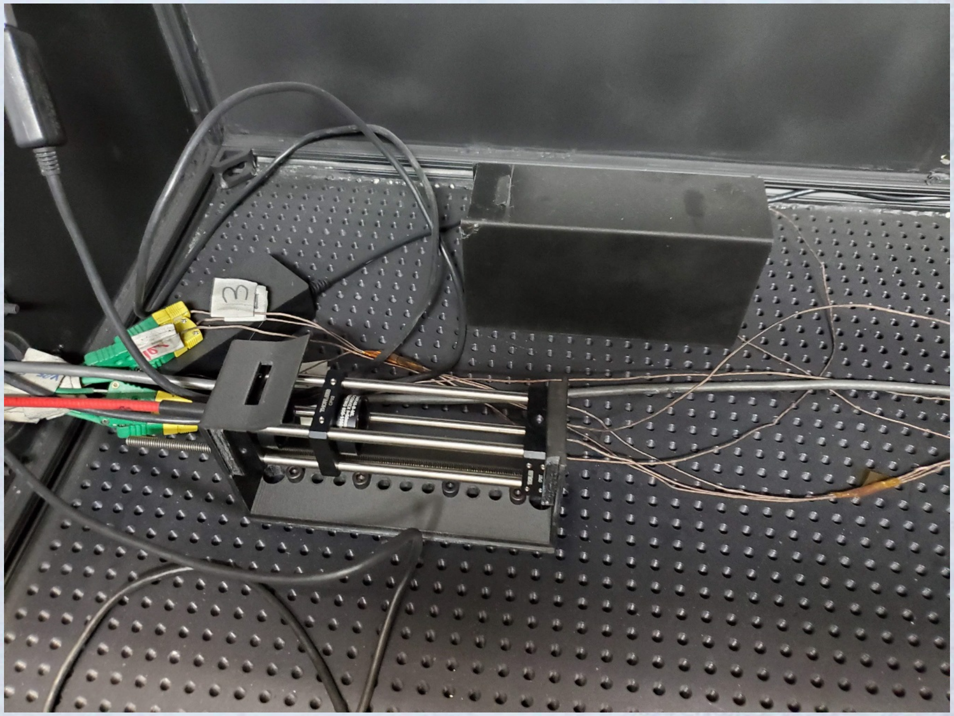


- 316 stainless enclosure framed with 8020, gasket sealed and light impermeable.
- HEPA filtered powered air evacuation can clear the chamber in ~3 minutes

- Fully adjustable panel lighting
- Remote access camera for viewing
- Interior coated to prevent light scatter
- Beam Reflection guard
- Cooling fan to reduce post test temp for fast turnaround

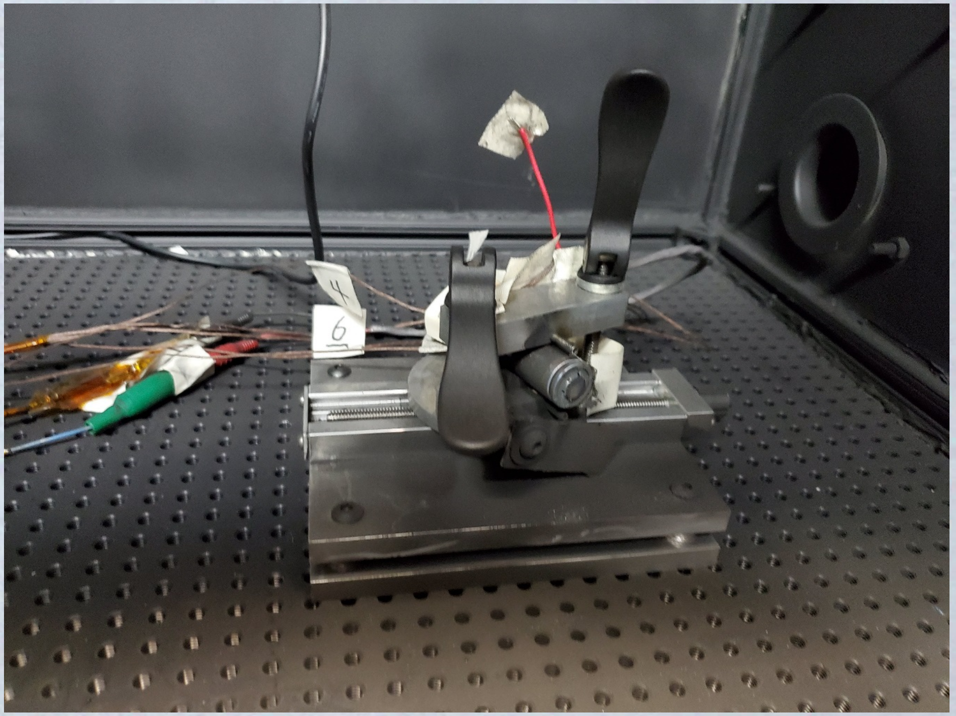
Test Hardware 2

Lens Enclosure



- Moveable lens enclosure with continuous adjustment and locking to fix focal distance, with dust shroud and sacrificial front lens

Cell Holding Fixture



- Three degree of freedom cell holding fixture allows for beam targeting
- Quick release clamps enable fast test article change

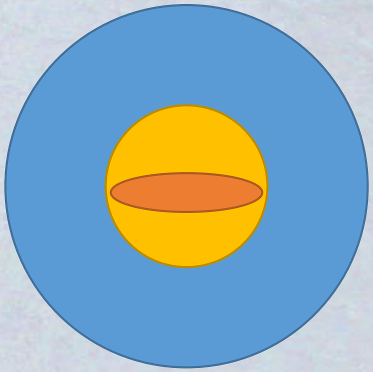
Results

Target Wattage (W)	Actual Wattage (W)	Dome %	Breach %	Average time to TR (s)	Standard Deviation (s)	Min (s)	Max (s)
40	37.8	60	20	78	51.83	15	160
50	48.2	80	40	24.6	27.81	6	80
60	57.6	100	20	17.8	8.77	5	28
70	67.3	100	100	16.2	12.93	8	42

- Total of 20 tests run for initial checkout, 5 at each wattage.
- Initial tests at Target zone C
- .41” beam diameter at can

Lessons Learned

- Uneven flux in beam target
- Coating Development improvement
  - Adhesion and diffusivity



Future Work

- Current method only tested on single 18650, plan is to move onto larger cells that have struggled with heater initiation
- Method to be adapted to pack level testing with fiber initiation
- System to be integrated with NASA Fractional Thermal Runaway Calorimeter
- New lens, coating, and laser wavelength studies need to be done, as well as varied cell can material.

Final Slide

Thank you!

For further information, please contact:

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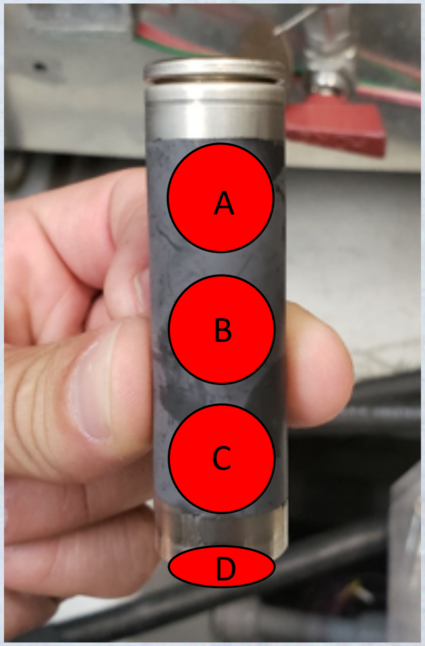
Backup Slides


A
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C
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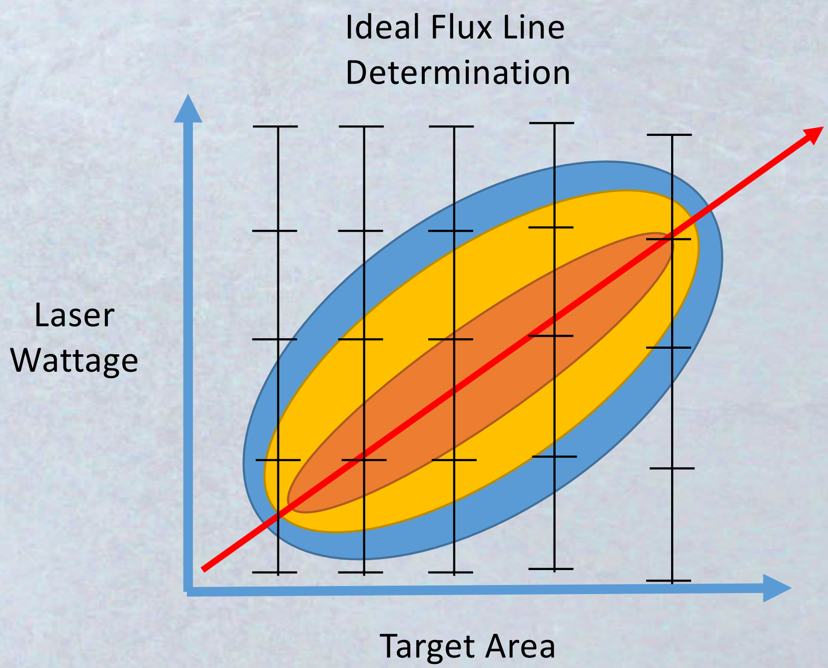
Ideal Flux Line
Determination
Laser
Wattage
Target Area