

Battery Cell Thermal Runaway Calorimeter

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Background / Problem Statement

We currently have several methods for determining total energy output of an 18650 lithium ion cell

We do not, however, have a good method for determining the fraction of energy that dissipates via conduction through the cell can vs the energy that is released in the form of ejecta.

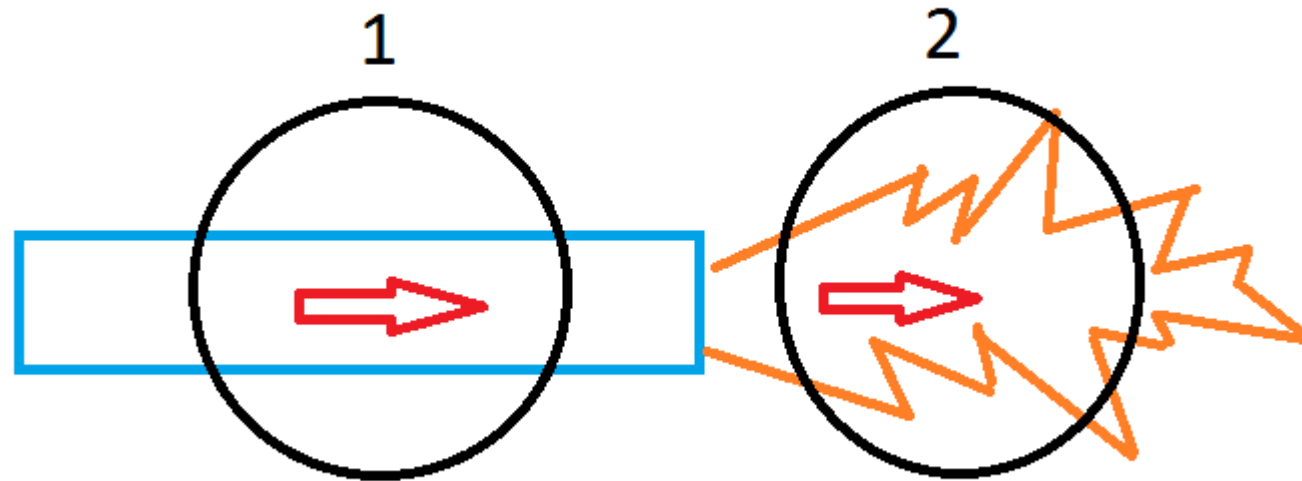
Knowledge of this fraction informs the design of our models, battery packs, and storage devices

- No longer need to assume cell stays together in modeling
- Increase efficiency of TR mitigation
- Shave off excess protection



Basic Method

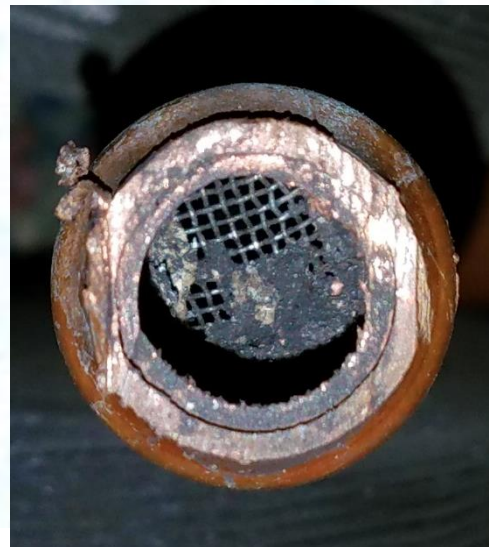
1. Cell is sent into TR.
2. Energy is absorbed by the can half (1) and the ejecta half (2).
3. Gases are released. (for now)
4. Change in temperature is used to determine energy input.





TR Calorimeter – Mark 1

- Design:
 - Copper cell chamber and ejecta chamber
 - Thermally isolated using macor ceramic washer
 - Coiled tubing ejecta chamber
 - filters installed under zoomlock crimp connectors
- Previous design performance was poor
 - Expensive macor piece broke each time the device was fired
 - Ejecta side was insufficient to capture all energy
 - Macor piece used a mechanical component and experienced shear forces in operation
 - Difficult to insulate





Calorimeter Mark 2



- The older coiled tube design was improved upon to yield this setup, where ejecta is decelerated by friction with the walls in the coil due to the sharp turns.
- This design has the advantage of requiring few parts and being very light, but presents other difficult challenges



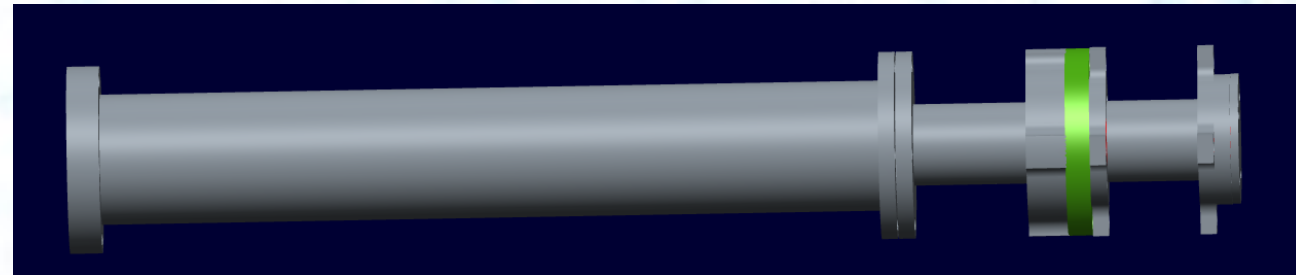


Mark 3

- Improvements in how the two chambers are thermally isolated and minimization of heat losses
- New technology disclosure submitted for patent consideration

Benefits include

- Gathers energy in minutes, rapidly reusable.
- Modular, can accept other cell or ejecta chambers
- Cheaply replaceable limited life parts





Calibration Method



Cell simulating heater



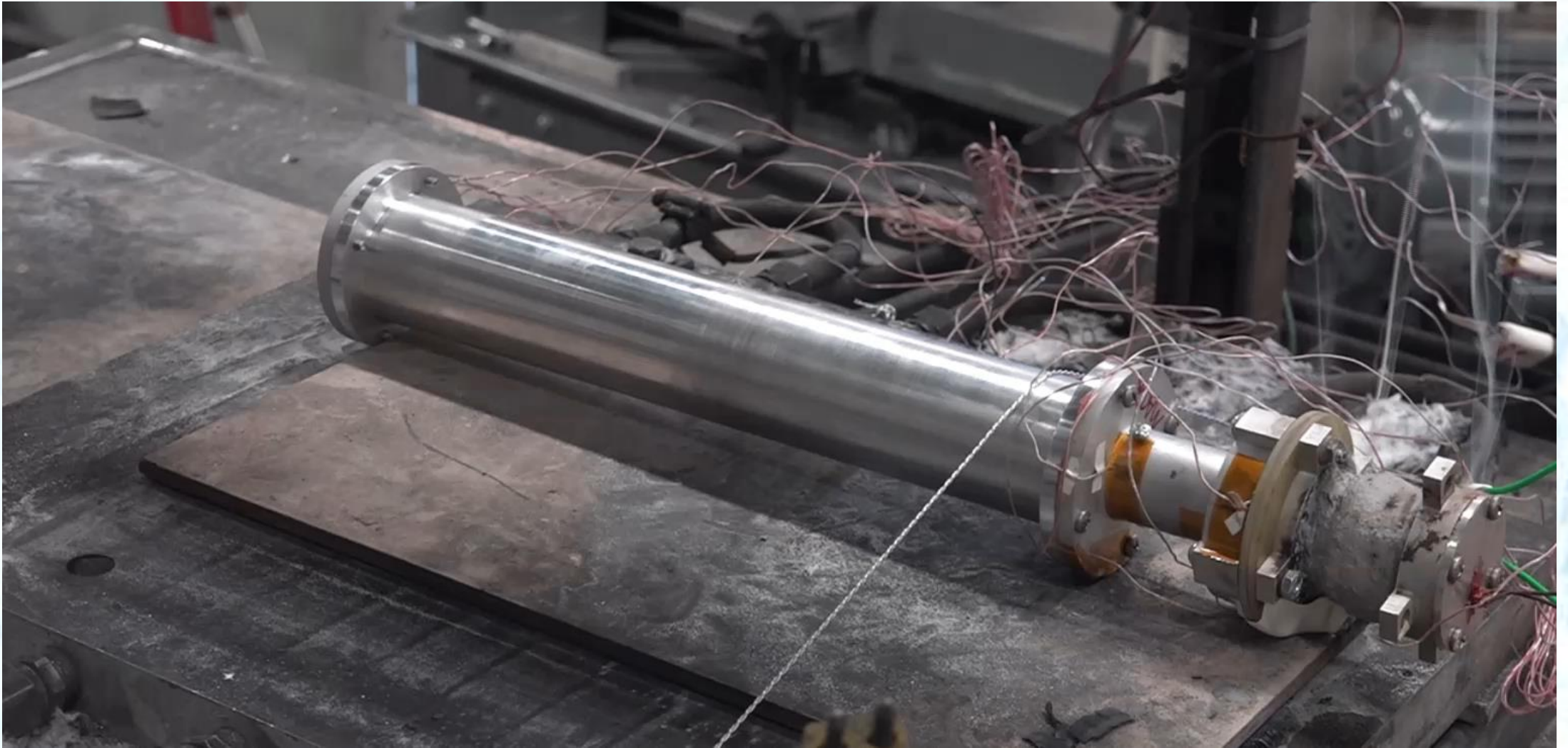
Simulating heater being fired

- Can also back out heat from pre-TR tc data



Run 18 Calorimeter Firing

Thermal Runaway Calorimeter



- Early run showing calorimeter in operation



Run 21 Calorimeter Firing

Thermal Runaway Calorimeter



- Nominal run, functions as intended, slowed by 25%



Run 22 Calorimeter Firing

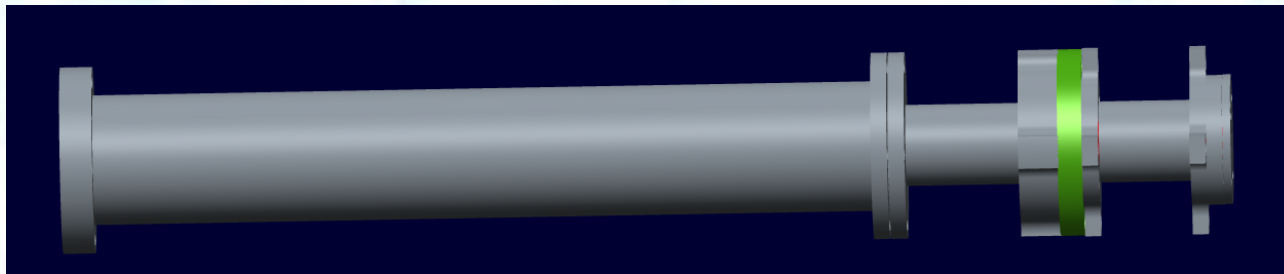
Thermal Runaway Calorimeter



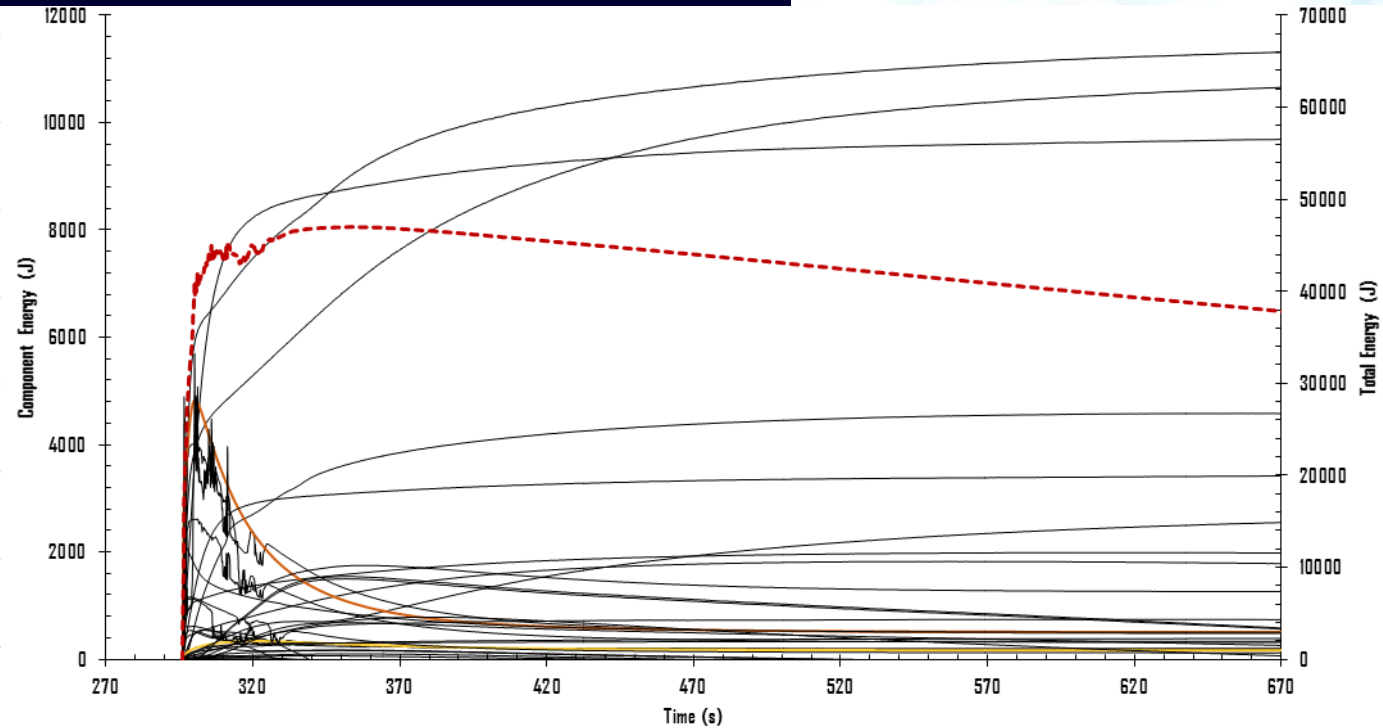
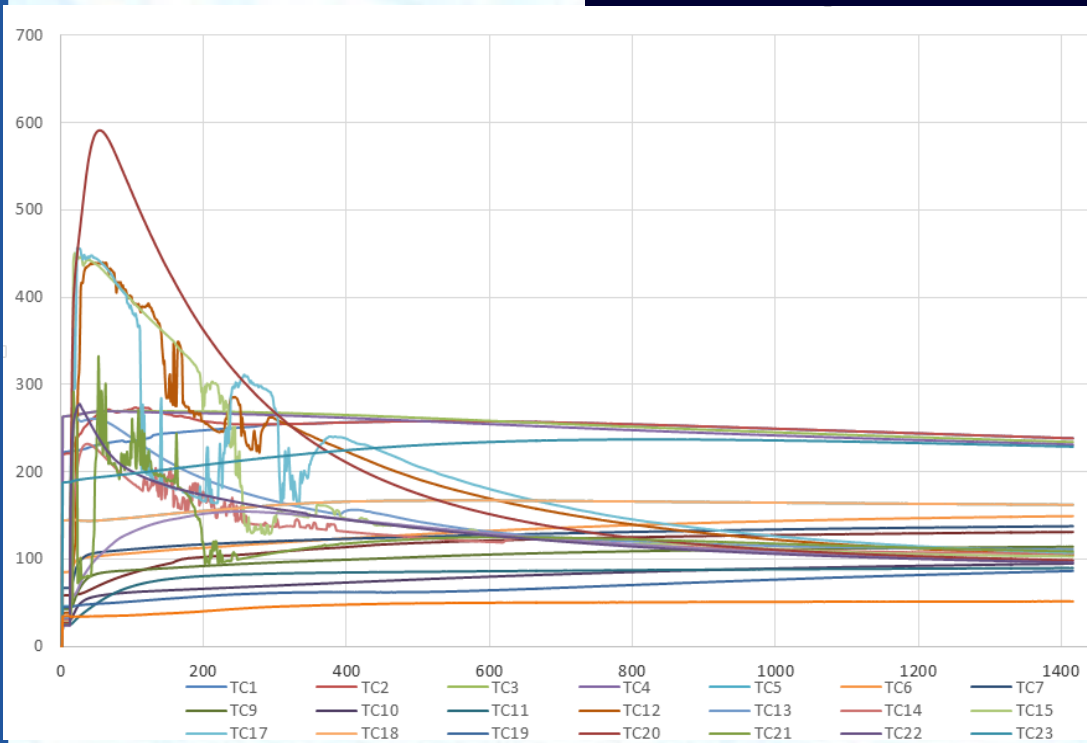
- Very violent TR, destroys ejecta internals, slowed 400%



Post Fire Analysis Example



Thermal Runaway Calorimeter



PRELIMINARY DATA



Takeaways

- This design is able to capture a significant portion of the energy and mass released during TR.
- Ejecta trapped in device can be studied for composition, massed, etc.
- Fine grained understanding of where energy goes during and after TR.
- Test turnaround time of hours or even minutes instead of days or weeks.
 - Allows us to do statistically significant number of tests on many cells
- Capable of being scaled up to work with larger or different cells.



Forward Work & Acknowledgements

Forward Work

- Hollow Threaded Rod
- Ceramic TCs
- Fire Resistant Gasket material
- Elimination of flutes in cell chamber
- Tally the energy content of vented gases.
- Ascertain composition and energy content of vented gas

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