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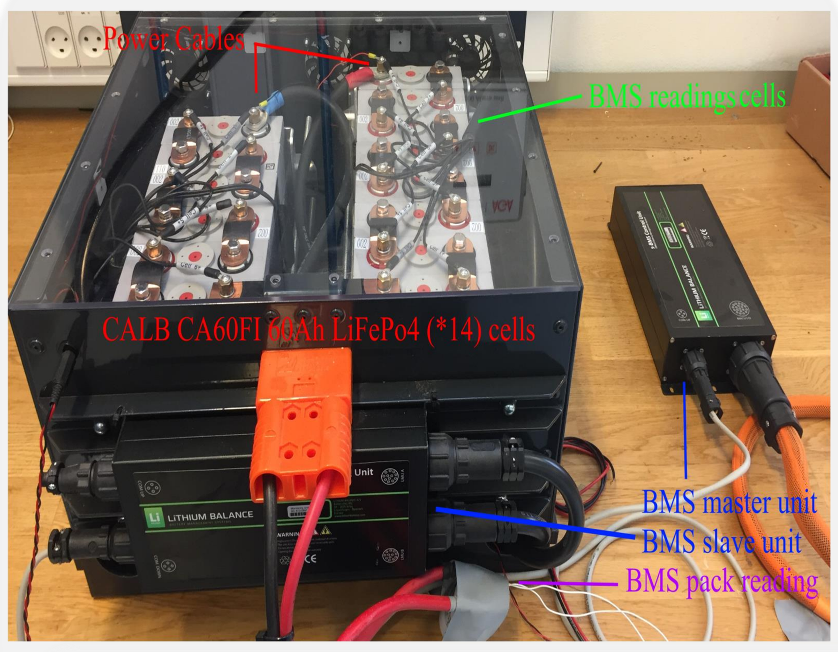
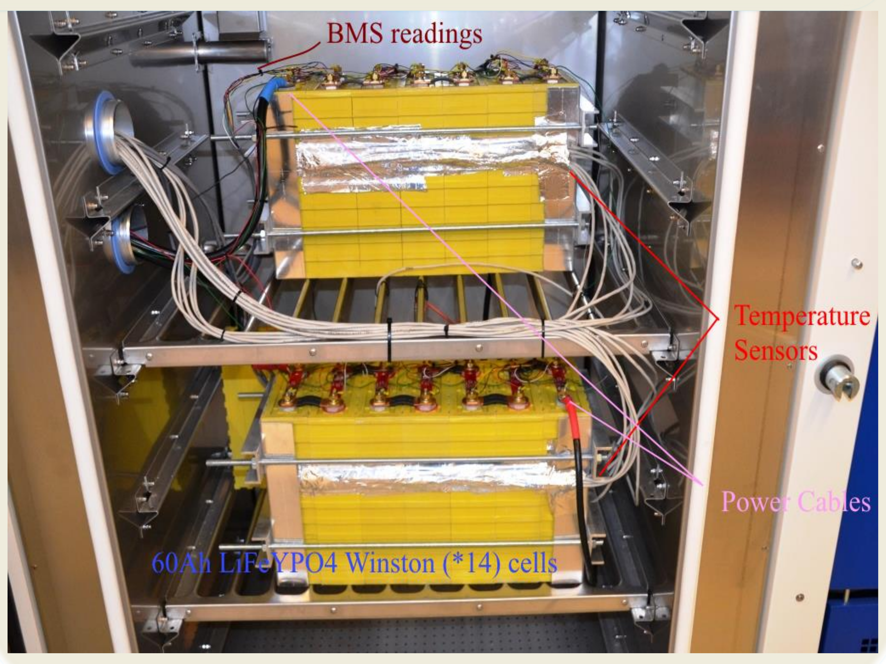
Motivation

Incremental Capacity Analysis (ICA) is a method used to investigate the capacity State-of-Health (SoH) of battery cells [1]. The aim of this poster is to present the challenges for implementing the ICA technique for battery packs, here consisted of 14 cells, by means of different C-rates (C/10, C/6 and C/5) and for several temperatures. LFP chemistry based cells are connected in series to build the packs, for either 60Ah and 160Ah.

Experimental Setup

14*Winston 160Ah LiFeYPO4 cells at C/6 between **5º** and **30ºC**

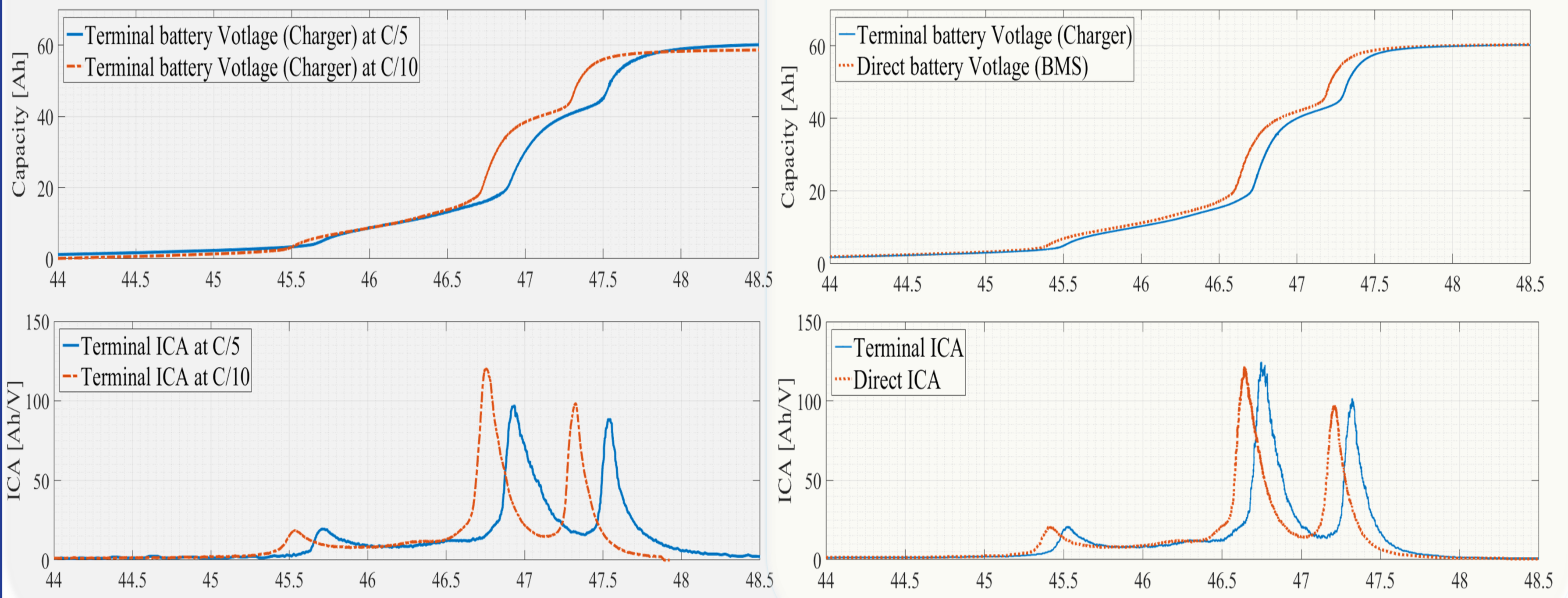




14*CALB 60Ah LiFePo4 cells at **C/5** and **C/10** charge current rate

Direct & Terminal ICA

- **Charge Voltages:** at C/10 & C/5
- **Charge Voltages:** at C/10 for Charger & BMS



ICA Method

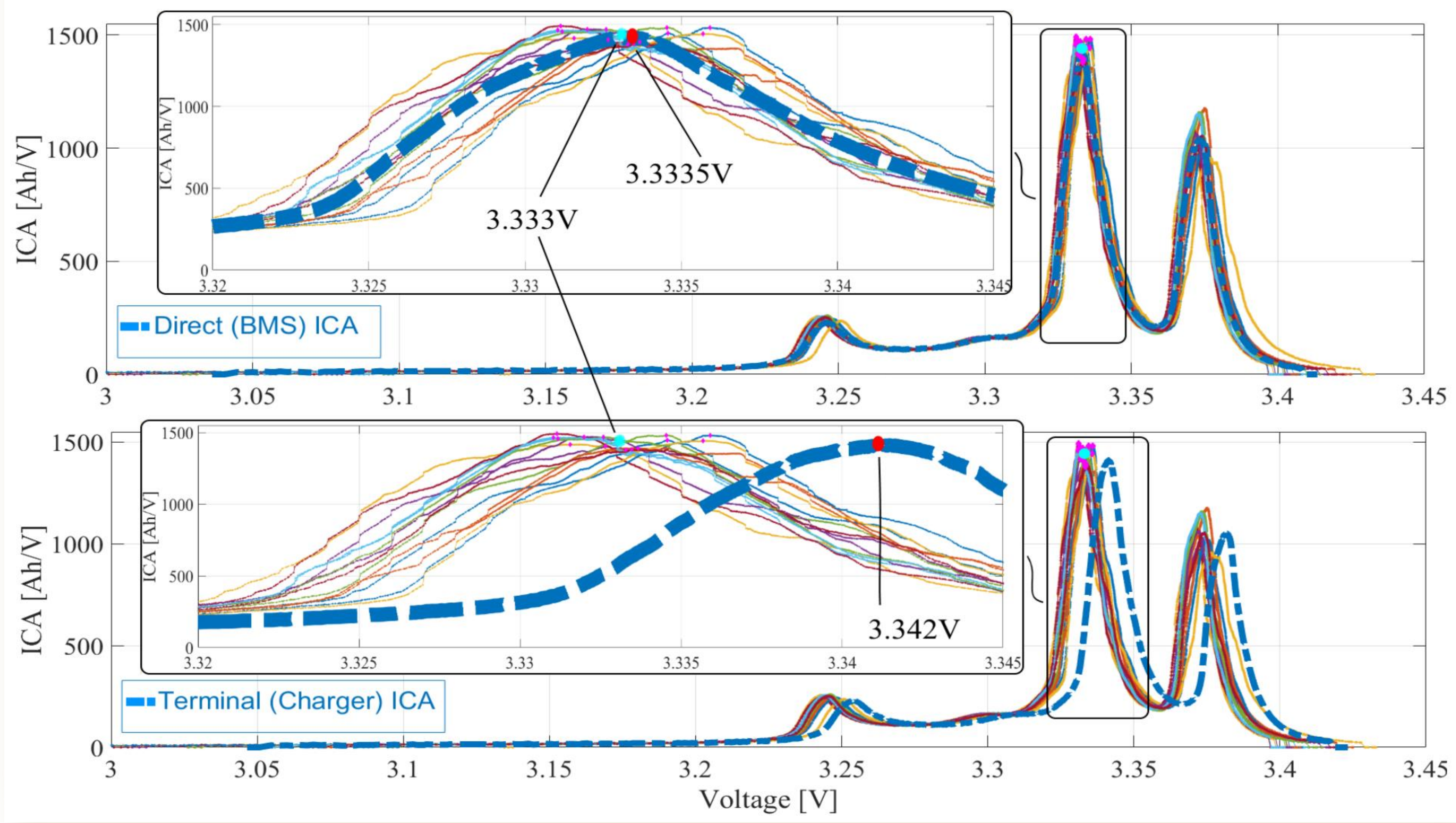
- **Incremental Capacity Analysis:**

$$IC = \frac{dQ}{dV}$$

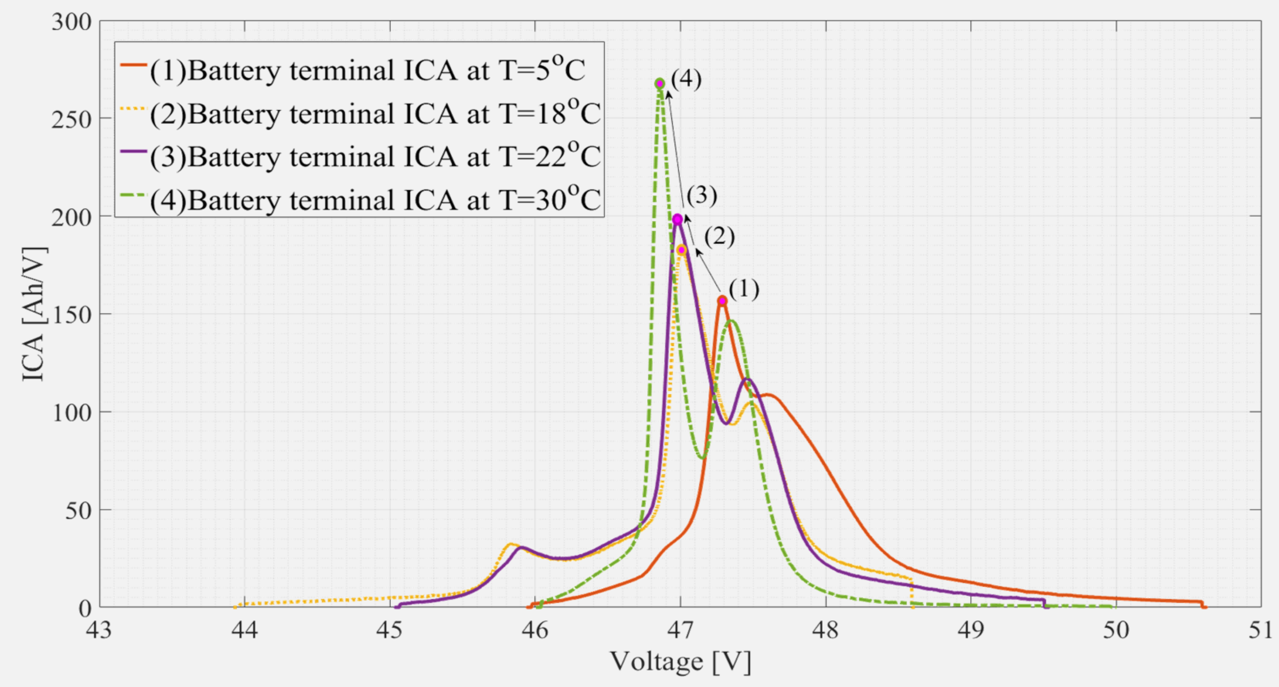
- At a chosen ΔV (5~25mV) [2]
- Several approaches in literature for wide range of chemistries, capacities and cell designs [3]
- For many different C-rates and temperatures [4]
- Significance at a battery pack level not yet established
- Smoothing of raw data and filtering of charge/discharge capacity curves, to achieve an identifiable and unique IC peak

Results

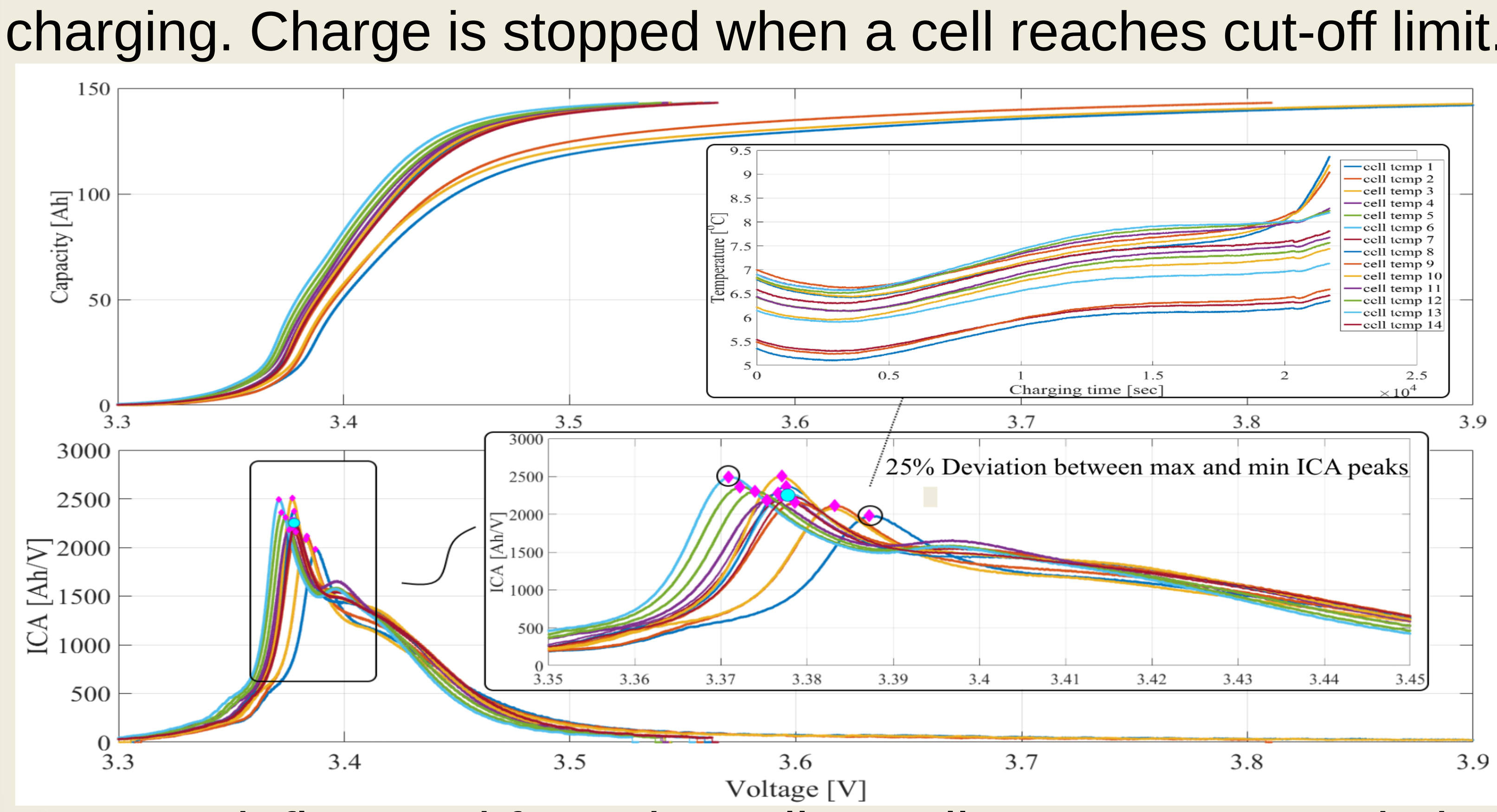
- **Direct ICA:** Less than 1mV deviation to the averaged cells ICA
  - ➢ Accurate cell capacity SoH estimation based on pack readings
- **Terminal ICA:** Approx. 10mV deviation to the averaged ICA



- Terminal ICA sees a higher impedance path compared to direct
- **Variable temperatures for C/6:** For the 160Ah battery pack. The peak moves to the lower voltage levels due to lower resistance, which is caused by a higher temperature



- ICAs influenced from temperature variations on the pack level
- **160Ah battery pack charged with C/6 at 5ºC :** spread of the individual cells' peaks due to inactivity of balancing during charging. Charge is stopped when a cell reaches cut-off limit.



- ICAs are influenced from the cell to cell temperature variation

Acknowledgement

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References

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[2] X. Han et al., J. Power Sources, **251**, 38–54 (2014) .
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[4] C. Weng et al., J. Power Sources, **235**, 36–44 (2013)

Conclusion & Future Work

- The additional Z path, the temperature variations and the C-rates must be considered for ICA on a battery pack.
- Terminal ICA is not deriving the actual capacity SoH of the cells.
- Outlook: Lifetime experiments at pack level under certain conditions.