Big data for the diagnosis and prognosis of deployed energy storage systems

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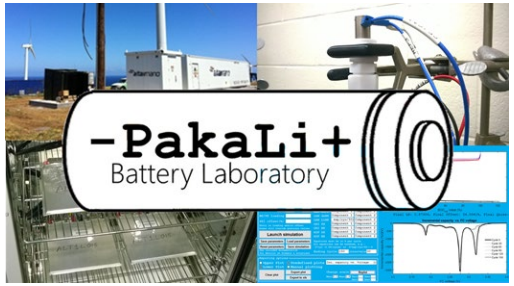

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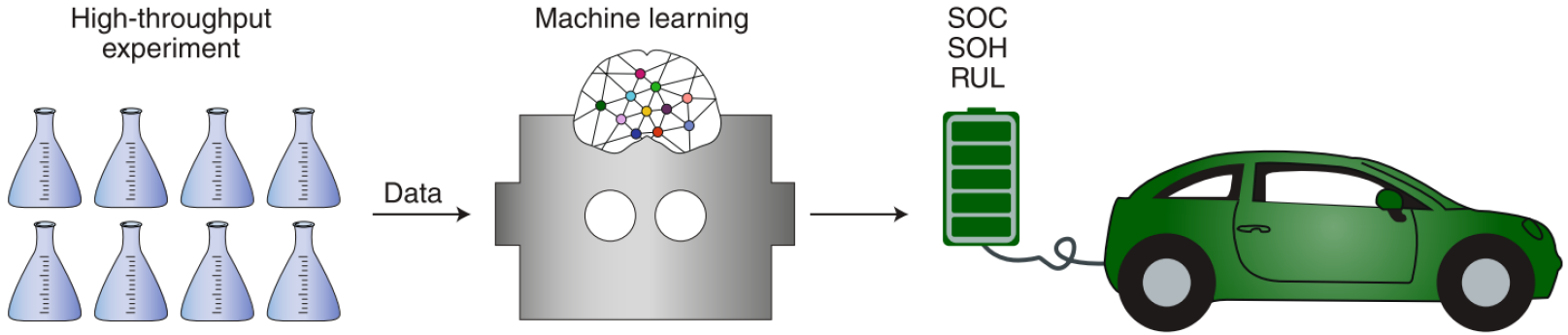
Big Data for Li-Ion Diagnosis and Prognosis

Artificial Intelligence

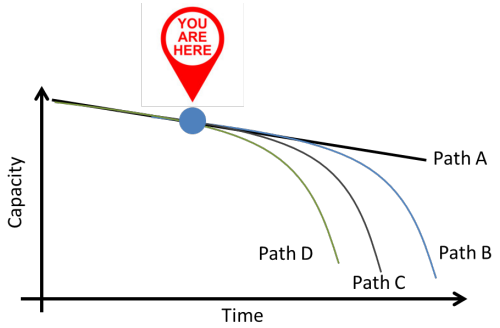
Objective/Significance



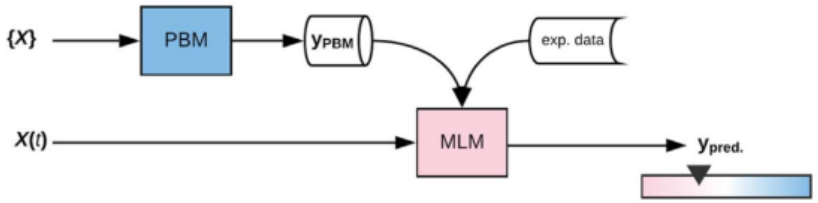
Man-Fai Ng et al., Nature Machine Intelligence, 2(3) p. 161-170 (2020)

Experimental data is costly and time consuming,
Most studies only test a couple batteries,
Biggest dataset: 124 batteries with only charge varying

Problematic because of path dependence.



Current state of the art is far from the big data needed to make AI work



Solution: Transfer Learning
Create synthetic training datasets

Aylol et al., Journal of The Electrochemical Society, 2021 168 030525
Dubarry M. et al. Journal of Power Sources 360 (2017) 59-69, Journal of Power Sources 479 (2020) 228806

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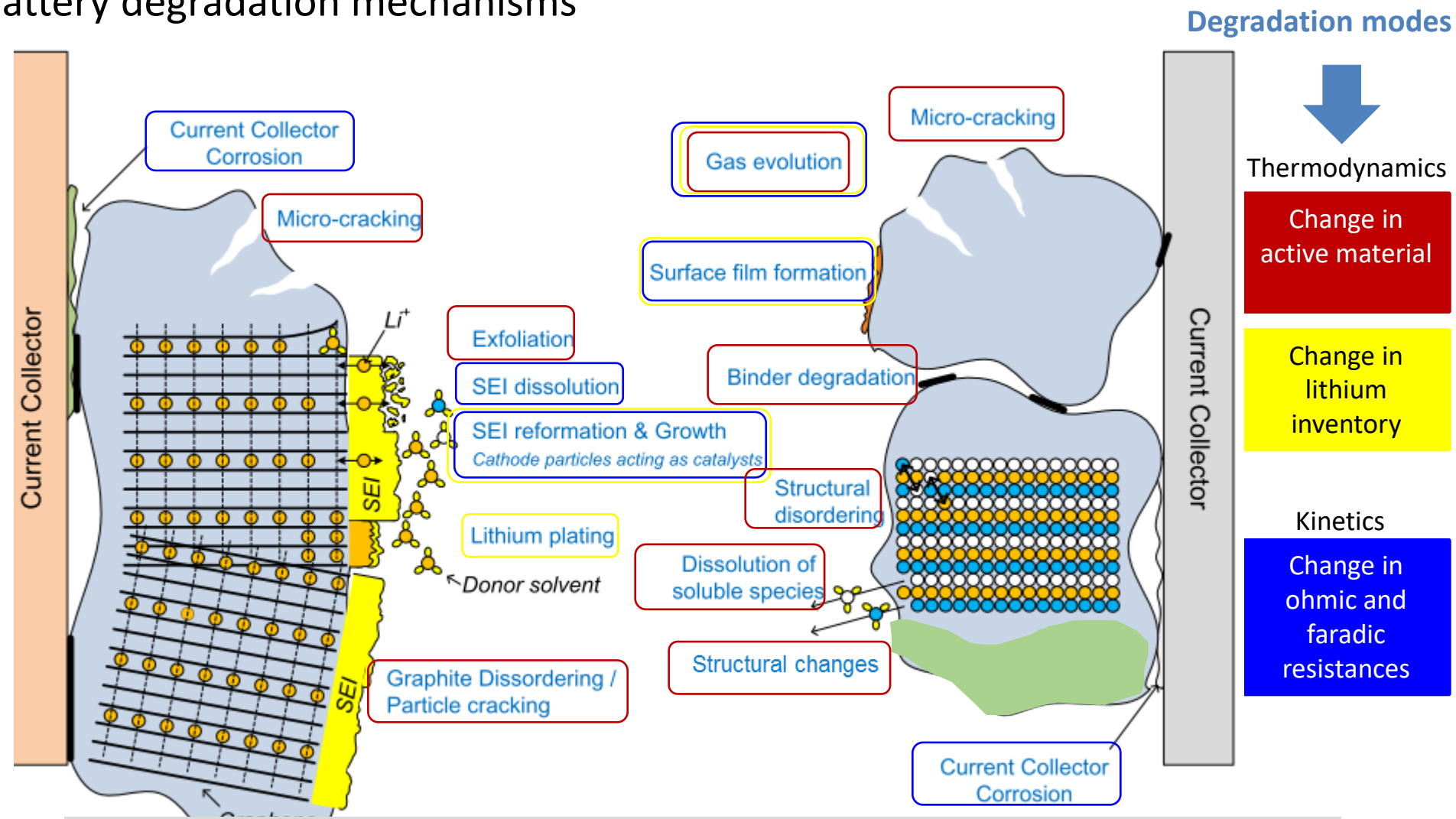
Li-ion batteries are complex systems

Lithium-ion battery degradation mechanisms



Degradation modes refer to **the impact of a mechanism rather than its root cause**.

M. Dubarry, C. Truchot and B.Y. Liaw, *J.Power Sources*, **219** (2012) 204-216

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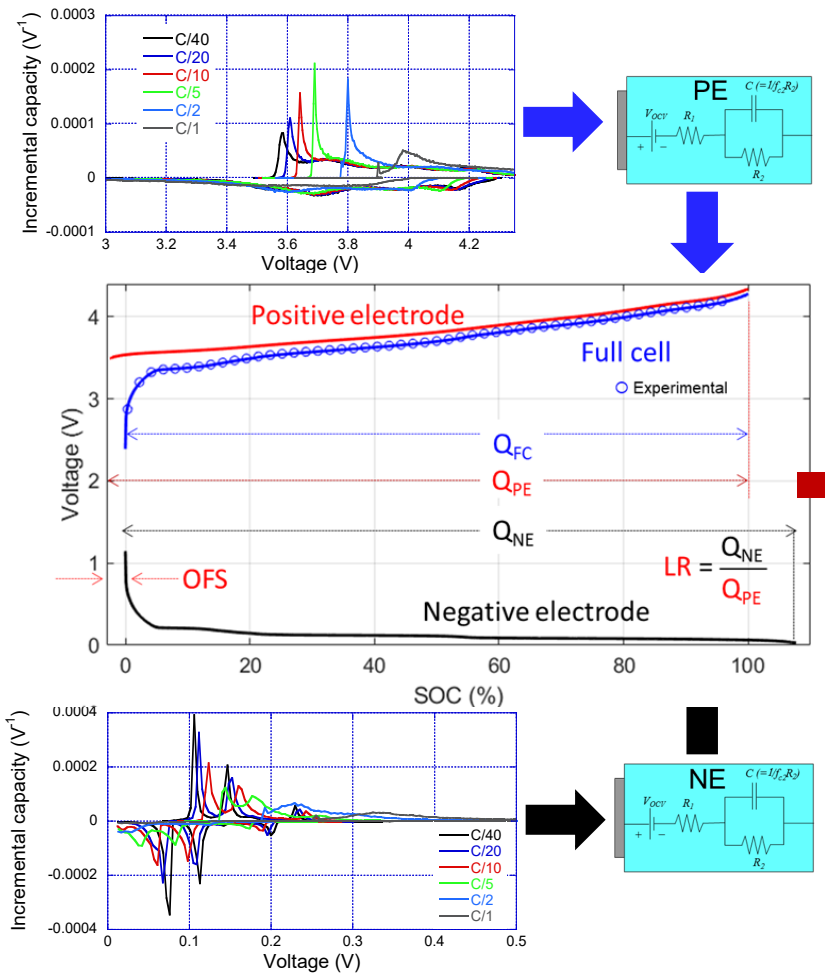
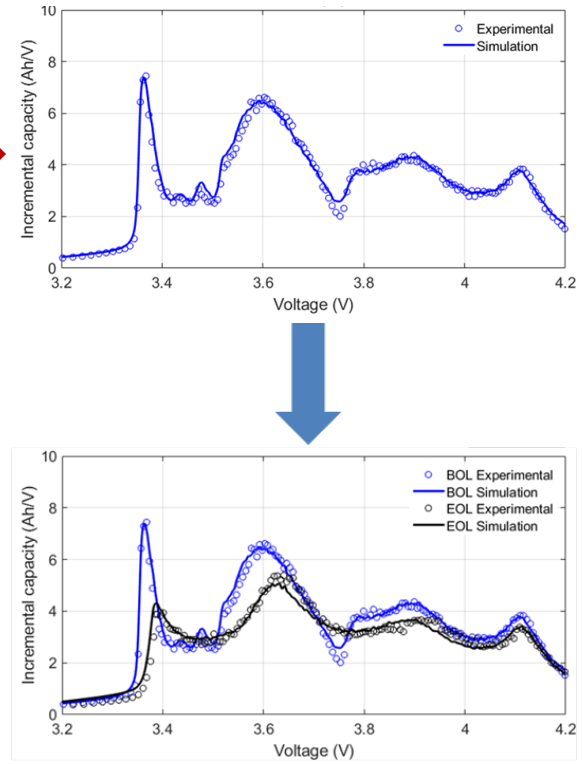
Building a Digital Twin: Mechanistic modeling

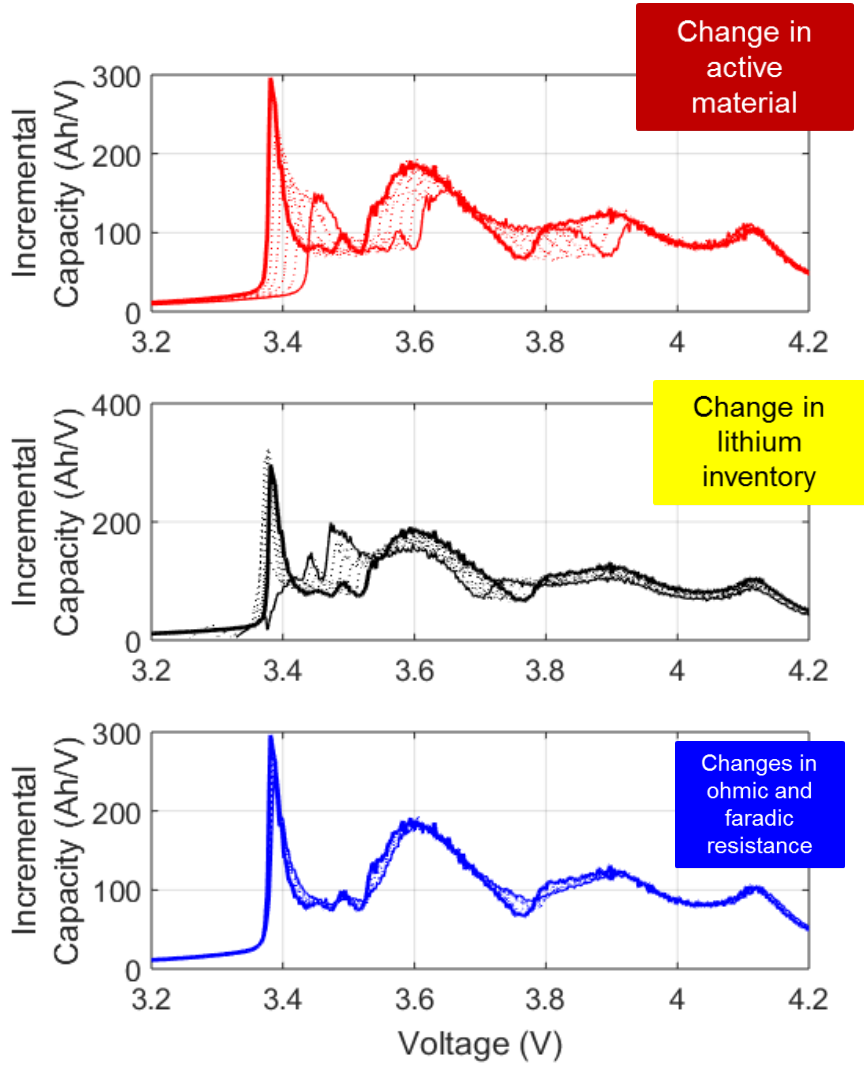
'alawa

General Principles





Vary matching parameters to emulate degradation



https://www.hnei.hawaii.edu/alawa/

Dubarry M. et al. Journal of Power Sources 219 (2012) 204-216

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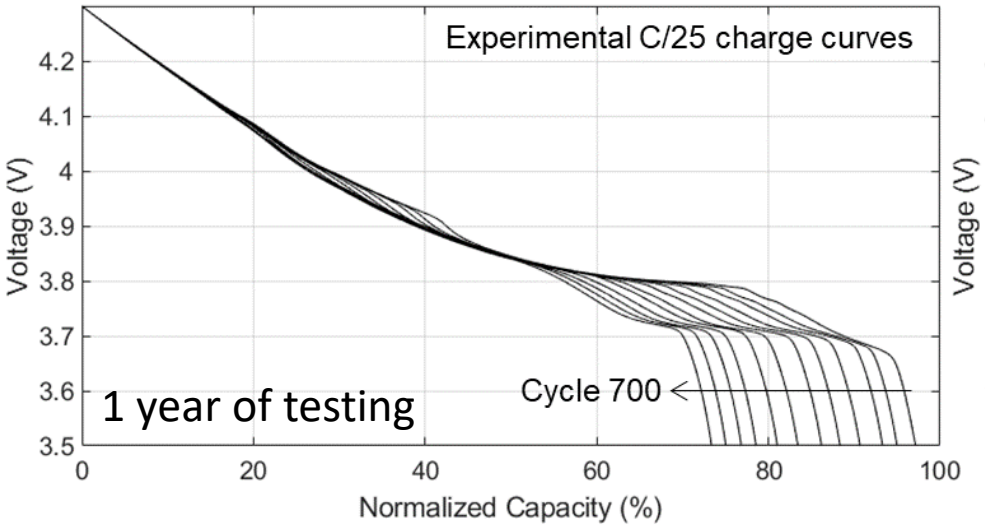
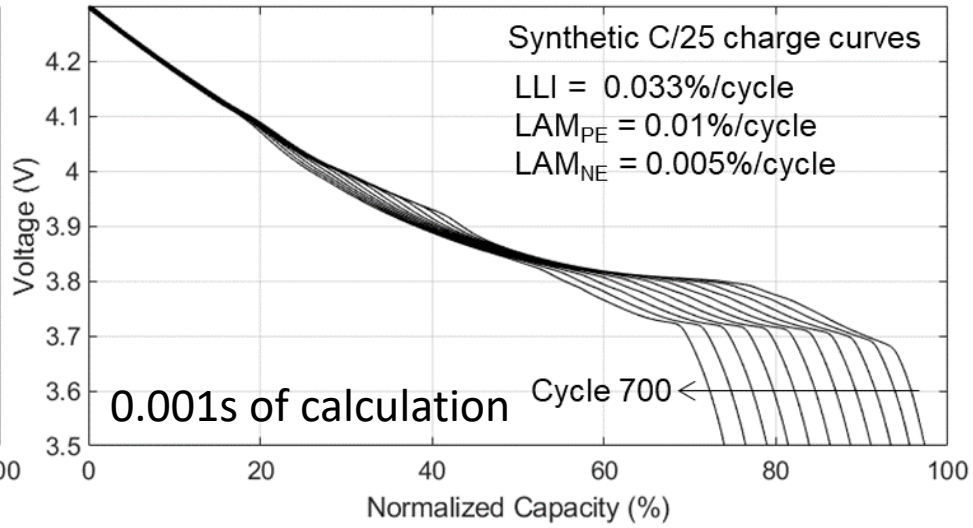
Simulate any possible degradation

'alawa

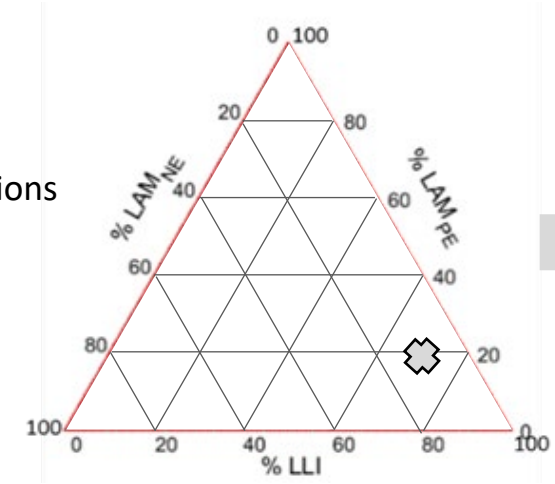
Emulation of battery electrochemical response

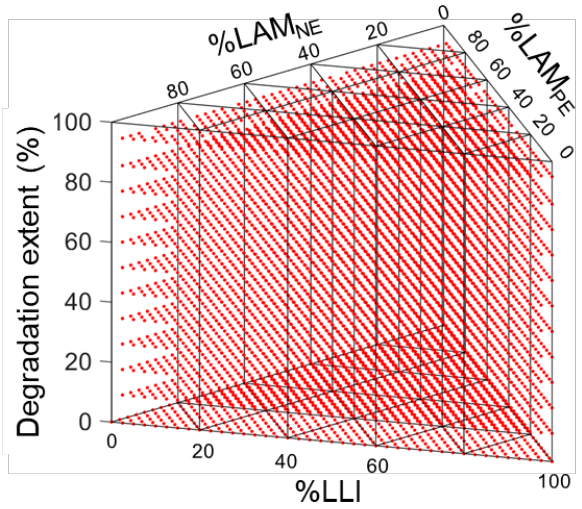




Aging reconstructed from simple equations

All possible degradations in ternary diagram:





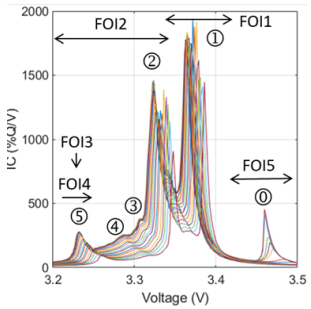
Infinite training data for diagnosis AI algorithms

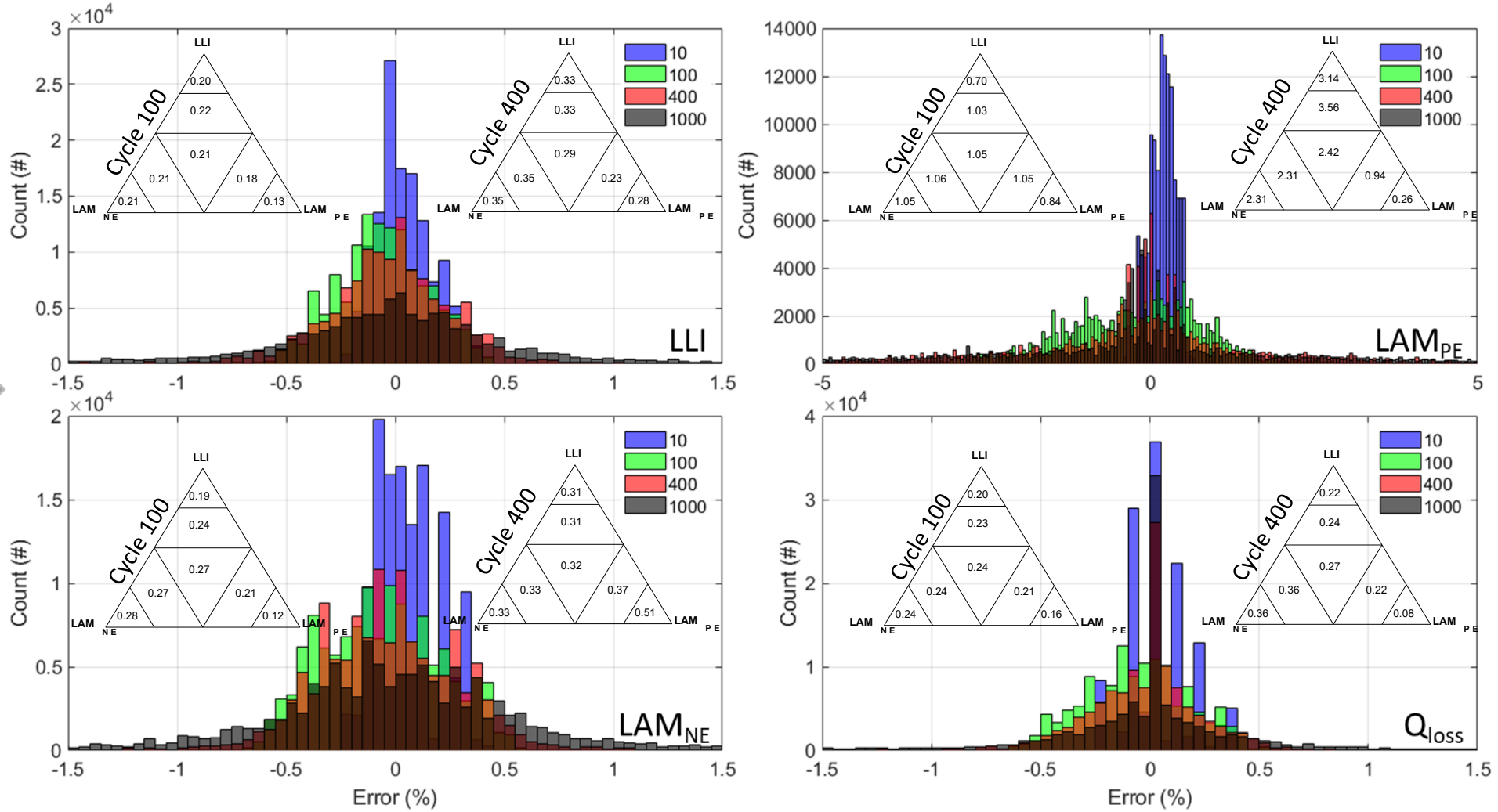
Mendeley Data, 2020; Vol. 2021, 10.17632/6s6ph9n8zg.3
Mendeley Data, 2020; Vol. 2021, 10.17632/bs2j56pn7y.3
Mendeley Data, 2021, 10.17632/2h8cpszy26.1
Mendeley Data, 2021, 10.17632/pb5xpv8z5r.1

Dubarry M. et al., Journal of Power Sources 479 (2020) 228806, Dubarry M. et al., Energies 2021, 14, 2371
Dubarry, M., et al. Journal of Power Sources **360**: 59-69 (2017)

Diagnosis

Example of data-driven diagnosis



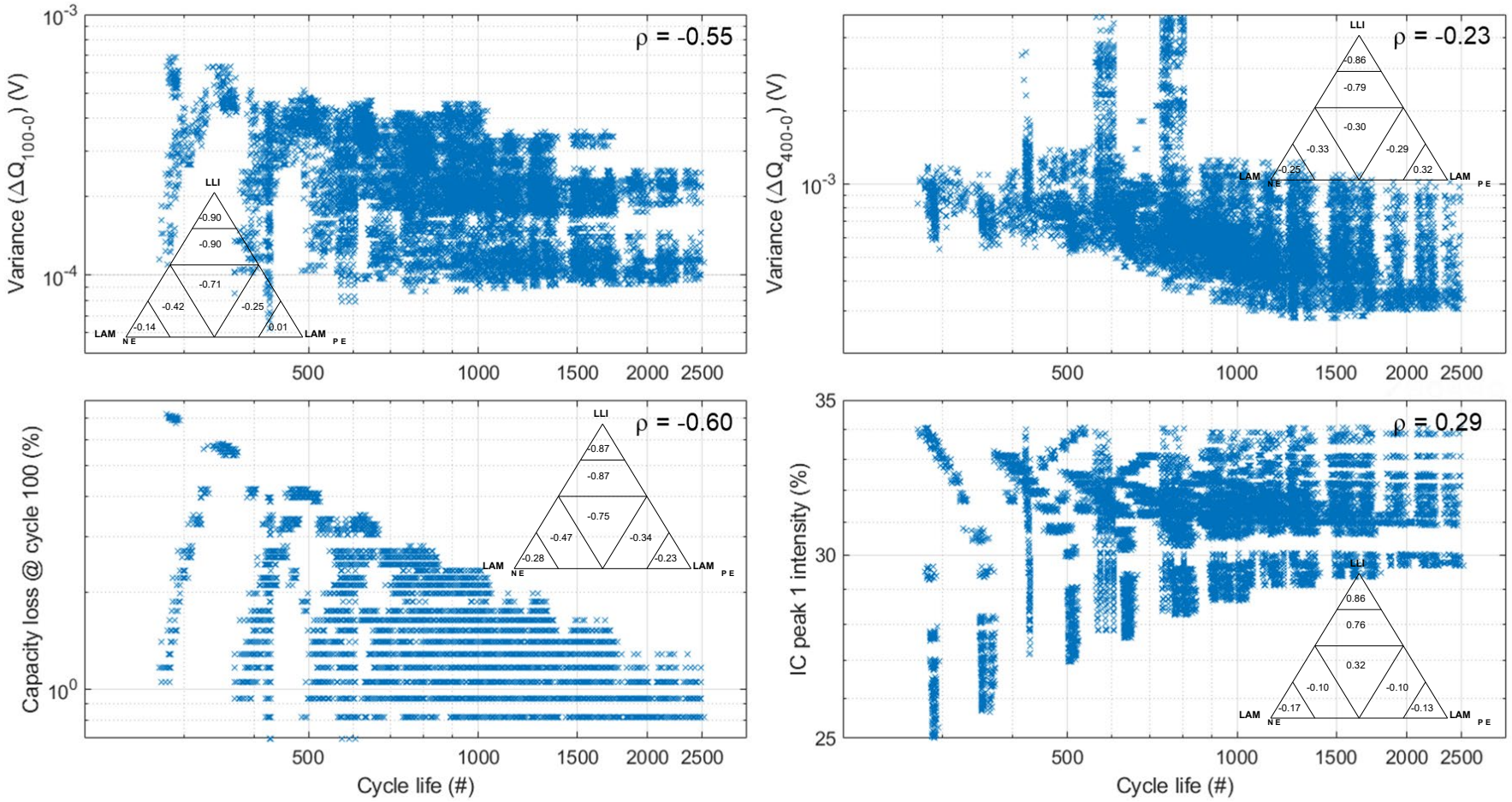


Dubarry M. et al., *Energies,* 2021, 14(9), 2371

Prognosis

Datasets can be used for training or for sensibility analysis.

What parameters can be used for early prognosis?



Dubarry M. et al., *Energies,* 2021, 14(9), 2371

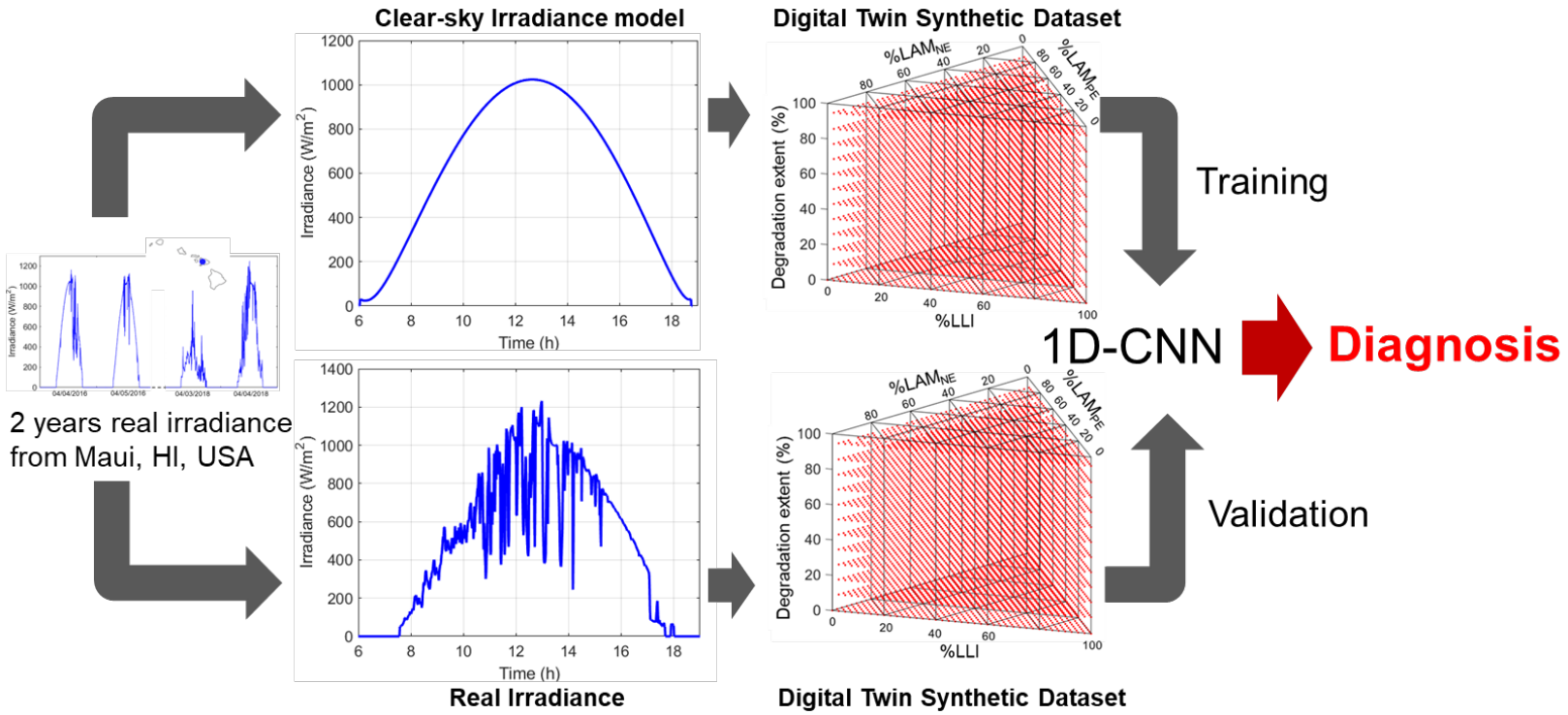
Data-Driven Diagnosis for PV Connected Batteries

Current Synthetic dataset approach for constant current data only

Not representative of deployed data (unless lengthy maintenance cycles)

Mechanistic model can be applied outside of constant current data

Emulation of clear sky irradiance: predictable power output under auspicious conditions



Dubarry M., Costa N., & Matthews D., Nature Communications, **14**, 3138
Dubarry M., Yasin F., Costa N., & Matthews D., Batteries 2023, 9, 395
Dubarry M. and D. Beck, Accounts of Material Research, 10.1021/accountsmr.2c00082

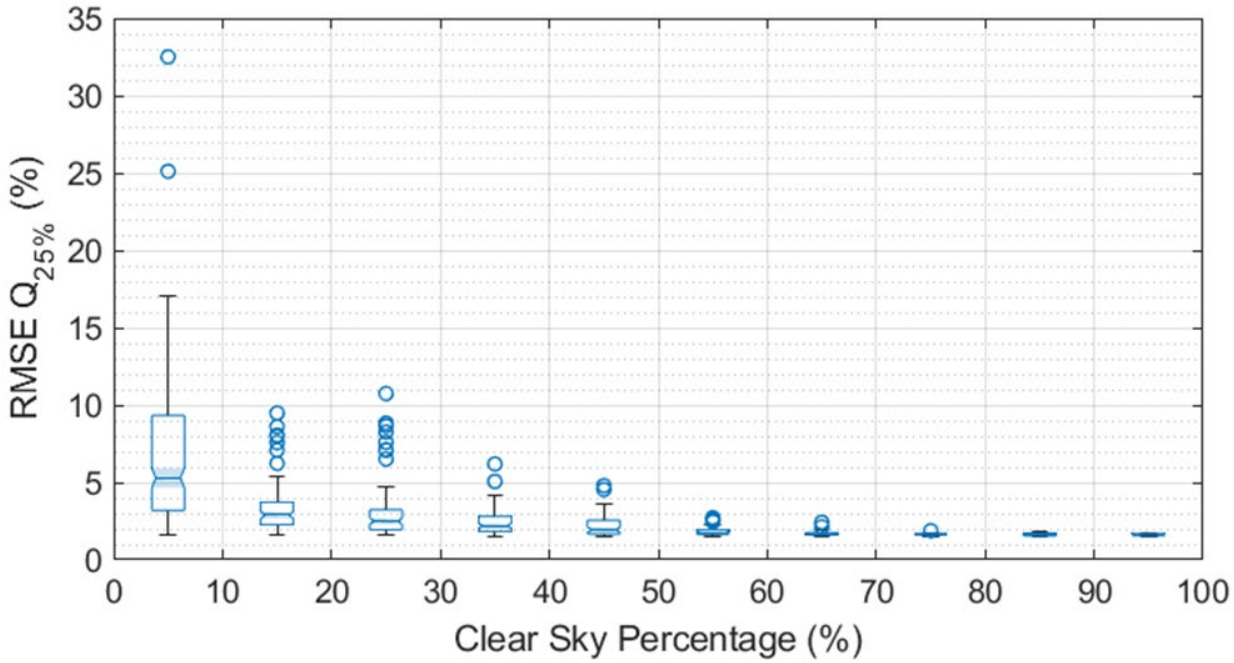
Data-Driven Diagnosis for PV Connected Batteries

Diagnosability tested on 1 ML algorithms for 2 years of data

720 days, 10000 degradation paths, up to 25% degradation in 1% increments

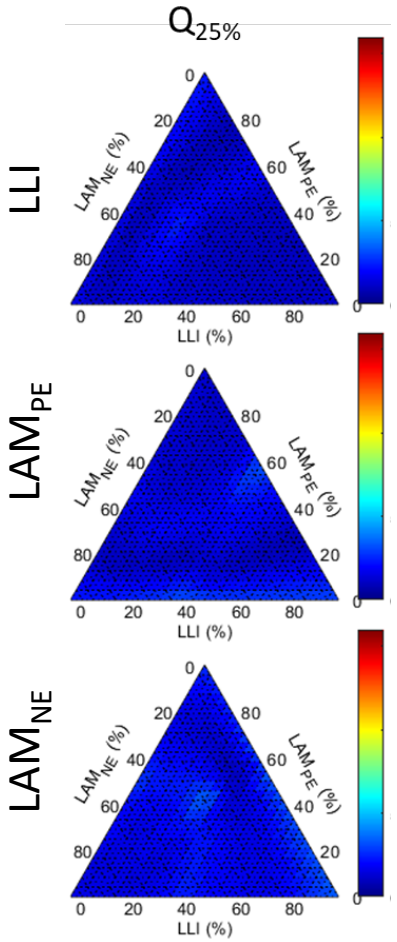
180,000,000 data points

Impact of cloud coverage

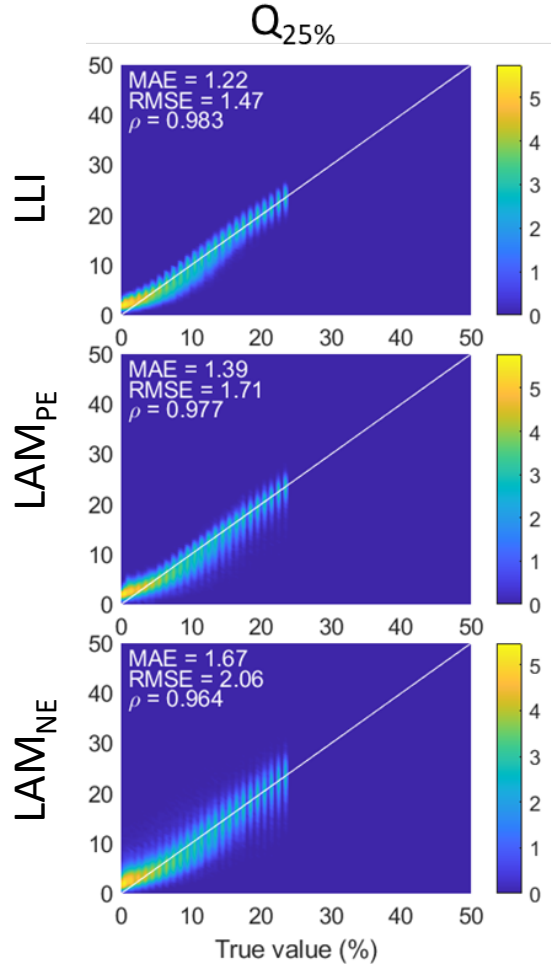


Plateaued above 50% clear sky

Impact of composition



Impact of extent



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Dubarry M., Yasin F., Costa N., & Matthews D., Batteries 2023, 9, 395

Big Data for Li-Ion Diagnosis and Prognosis
Take Home Message

Proof-of-concept methodology to generate **big data training datasets**

Universal tool for creation of data indistinguishable from real one

Broad applicability: cell chemistries, designs, and operating modes

Methodology could be **applied to different conditions** such as rate and temperature

Can handle **lithium plating with adjustable reversibility**

Ideal to **test validity** of different approaches for diagnosis or prognosis

The approach **does not remove the need for experimental testing**

It is still essential, and the only way, to decipher which conditions cater to specific degradation.

Acknowledgments

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Thank you!

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