



HAL
open science

Accelerated rate calorimetry dedicated to the modelling of Li-ion batteries thermal runaway of fresh and aged cells

Sara Abada, Martin Petit, Amandine Lecocq, Guy Marlair, Valérie Sauvant-Moynot, François Huet

► **To cite this version:**

Sara Abada, Martin Petit, Amandine Lecocq, Guy Marlair, Valérie Sauvant-Moynot, et al.. Accelerated rate calorimetry dedicated to the modelling of Li-ion batteries thermal runaway of fresh and aged cells. 48ème édition des Journées de Calorimétrie et d'Analyse Thermique (JCAT48), May 2017, Rueil-Malmaison, France. hal-04017372

HAL Id: hal-04017372

<https://hal.science/hal-04017372v1>

Submitted on 14 Mar 2023

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



Distributed under a Creative Commons Attribution 4.0 International License

Accelerated rate calorimetry dedicated to the modelling of Li-ion batteries thermal runaway of fresh and aged cells

Sara Abada¹, Martin Petit^{1*}, Amandine Lecocq², Guy Marlair², Valérie Sauvart-Moynot¹, François Huet³

¹IFP Energies Nouvelles, Rond-Point de l'échangeur de Solaize, BP 3 - 69360 Solaize, France *sara.abada@ifpen.fr

²INERIS Parc Technologique ALATA - BP 2 60550 Verneuil-en-Halatte, France

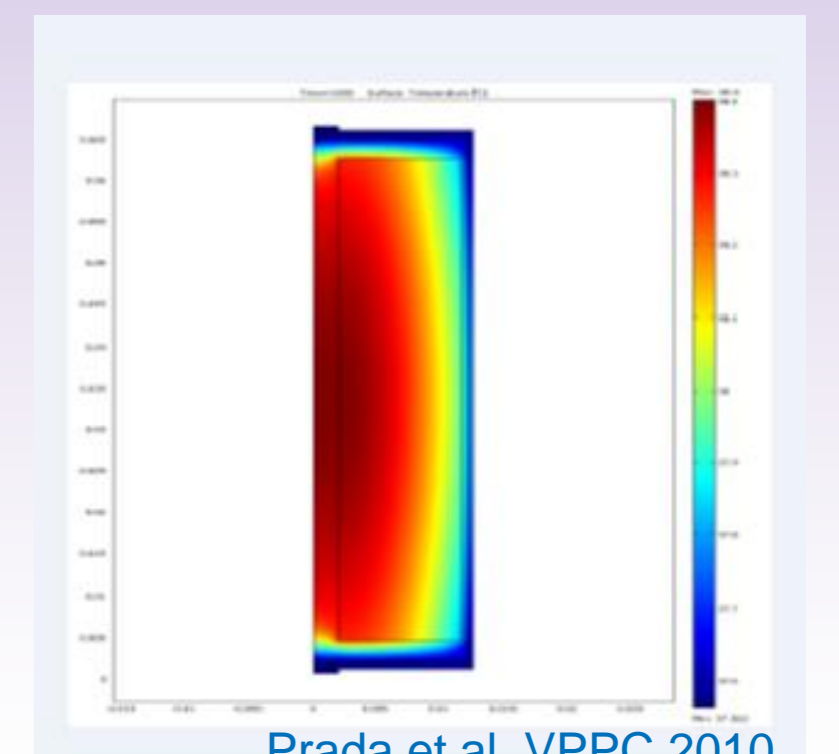
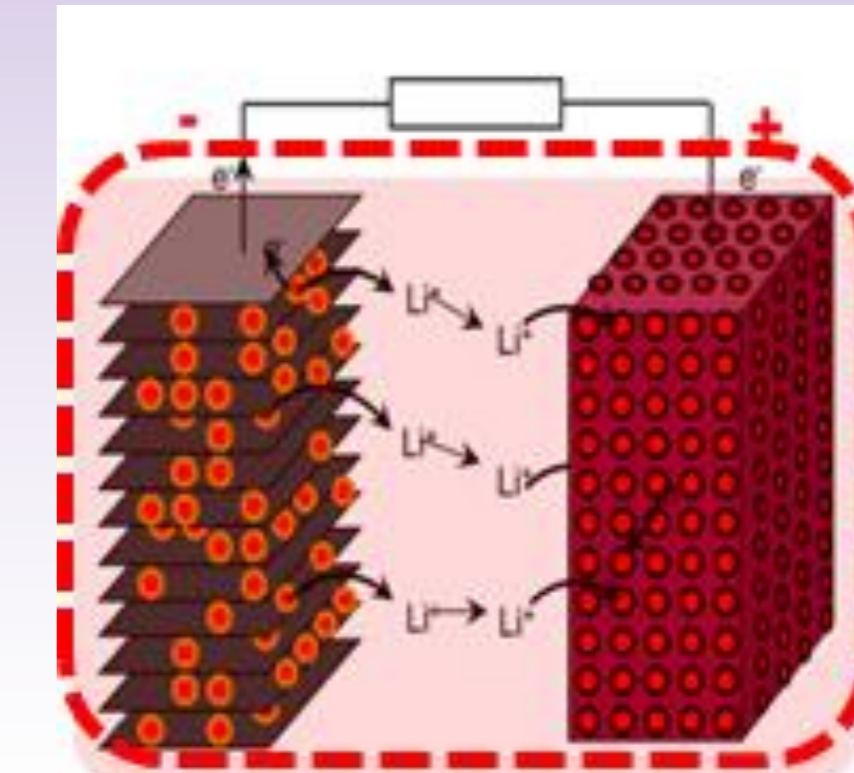
³UMR8235 - LISE; CNRS; UPMC Univ Paris 06, F-75005 Paris, France



CONTEXT & GOAL

- **Li-ion rechargeable batteries** are currently the preferred solution to store electrical energy.
- Many incidents on different applications are related to **battery safety**.
- **The thermal runaway** has been identified as a major safety concern with Li-ion batteries on their full value chain¹.

➔ Develop and validate physical and 3D model of Li-ion battery electro-thermal behavior nearby thermal runaway conditions, for a better understanding of phenomena as basis for improved engineering.

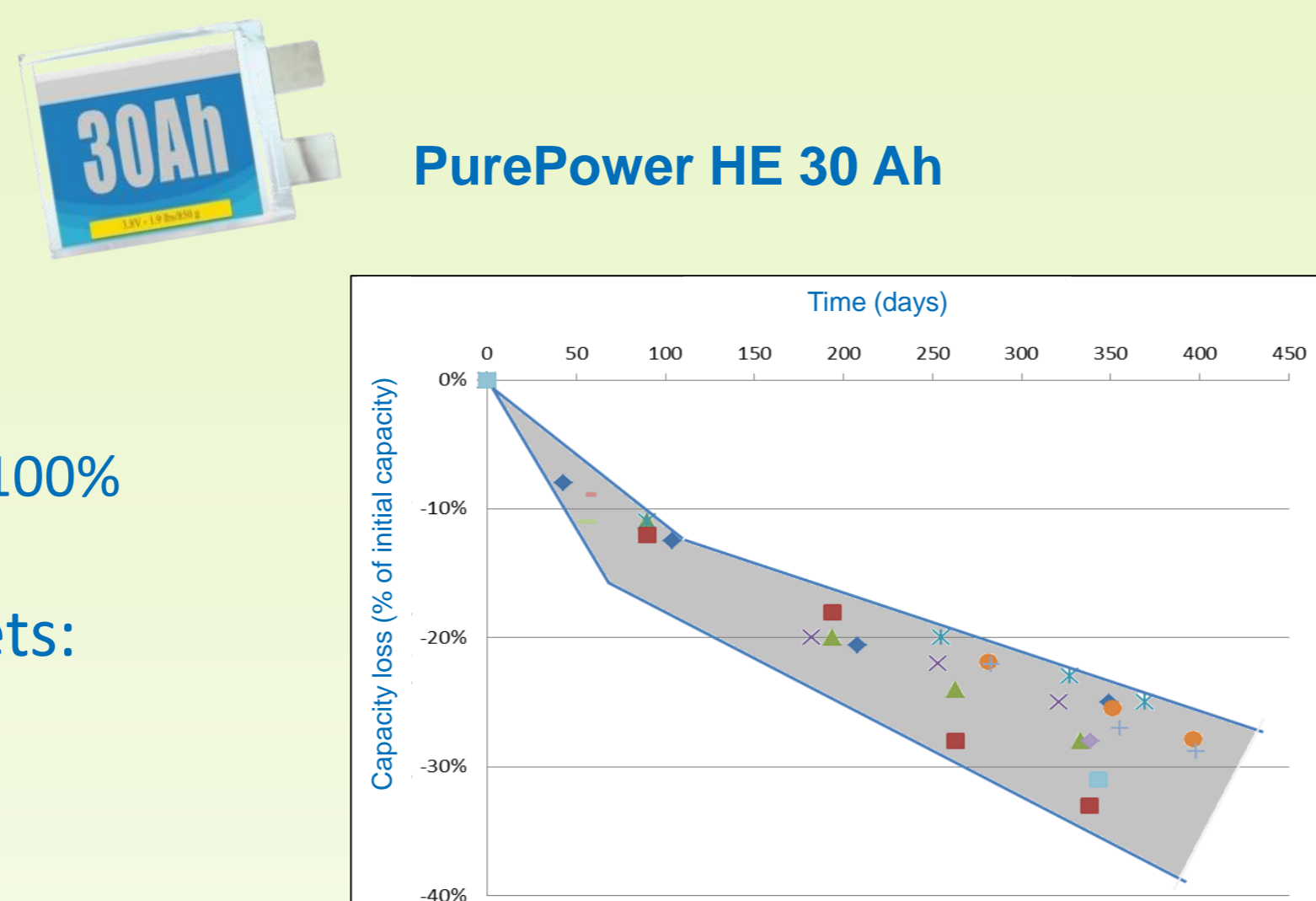


Prada et al, VPPC 2010

COUPLED MODELING/EXPERIMENTAL APPROACH

Experiments

- Choice of 3 relevant technologies
 - 2 LFP/C cells
 - 1 NMC/C cell
- Calendar aging of cells
 - Accelerated aging
 - @ high State of Charge (SOC): 100%
 - @ high Temperature : 60 ° C
 - In order to reach 2 aging targets:
 - 10 % of capacity loss
 - 30% of capacity losses
- Abusive tests
 - Heat-Wait and Search on Battery Testing Calorimeter (BTC) device for model calibration and validation

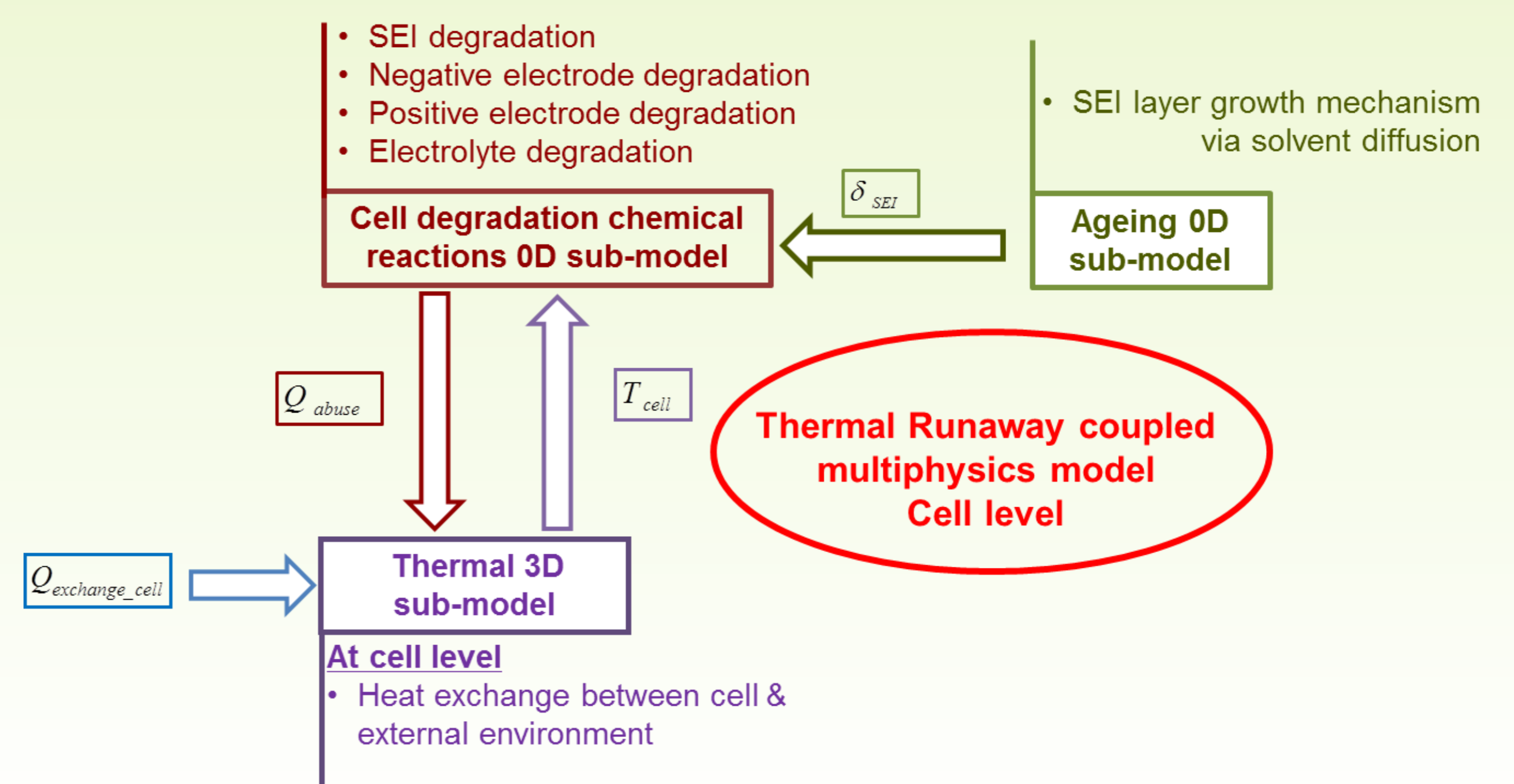


Before After BTC



Modeling

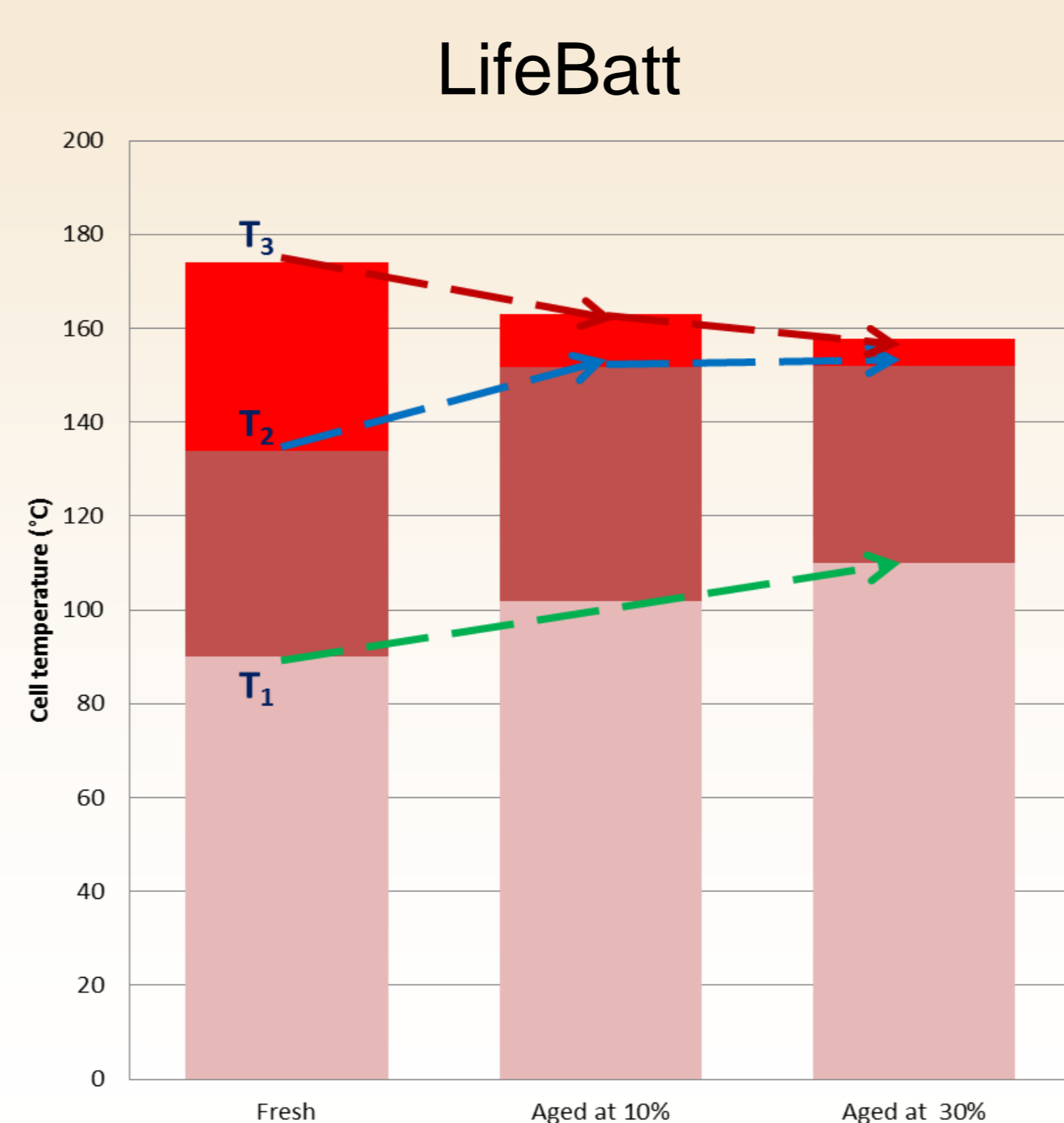
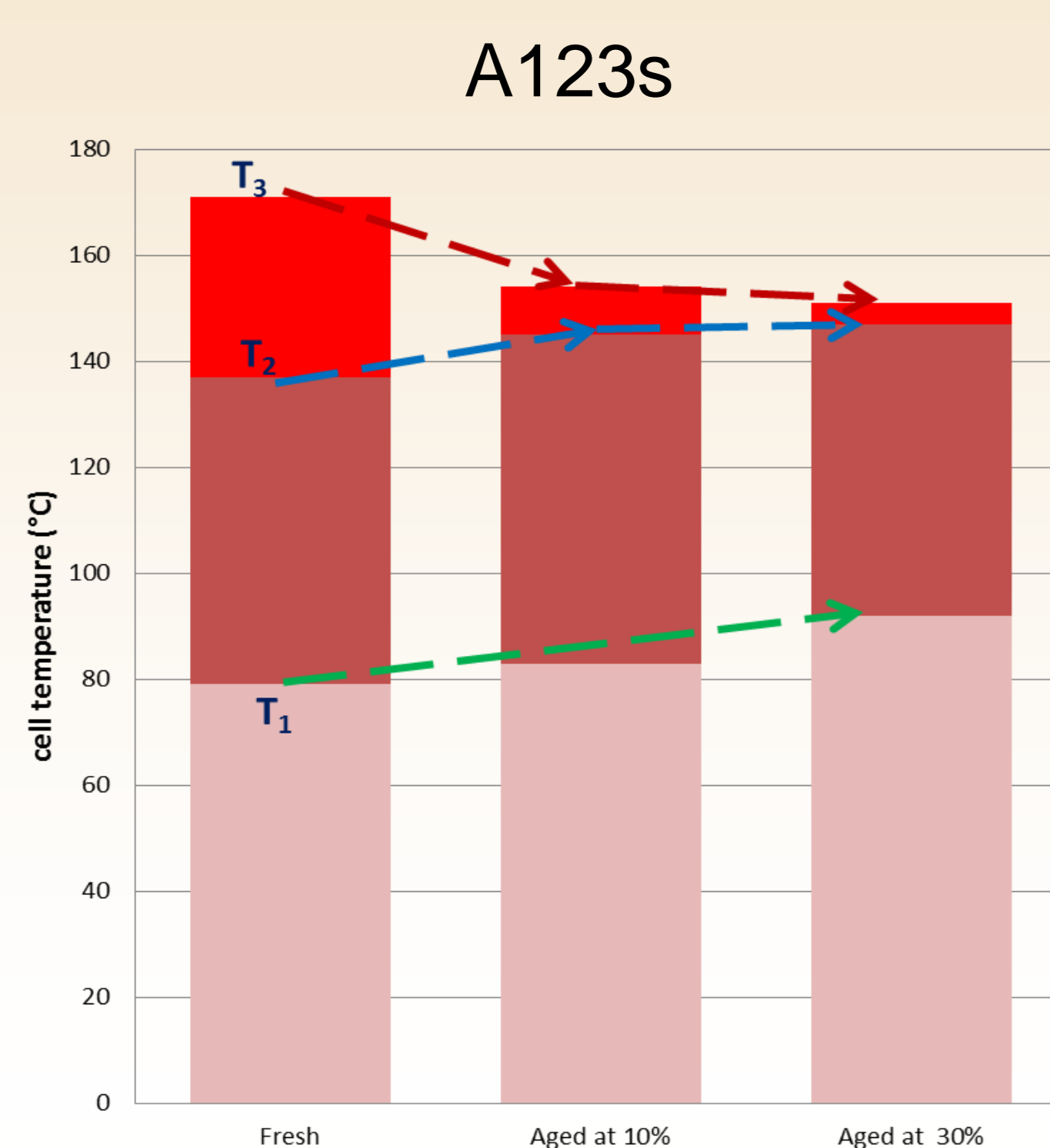
- Coupling of 3 submodels
 - 3D thermal model
 - Static aging submodel
 - Taking into account the formation of a SEI layer on the negative electrode
 - 0D cell chemical degradation model
 - Based on the four main degradation mechanisms



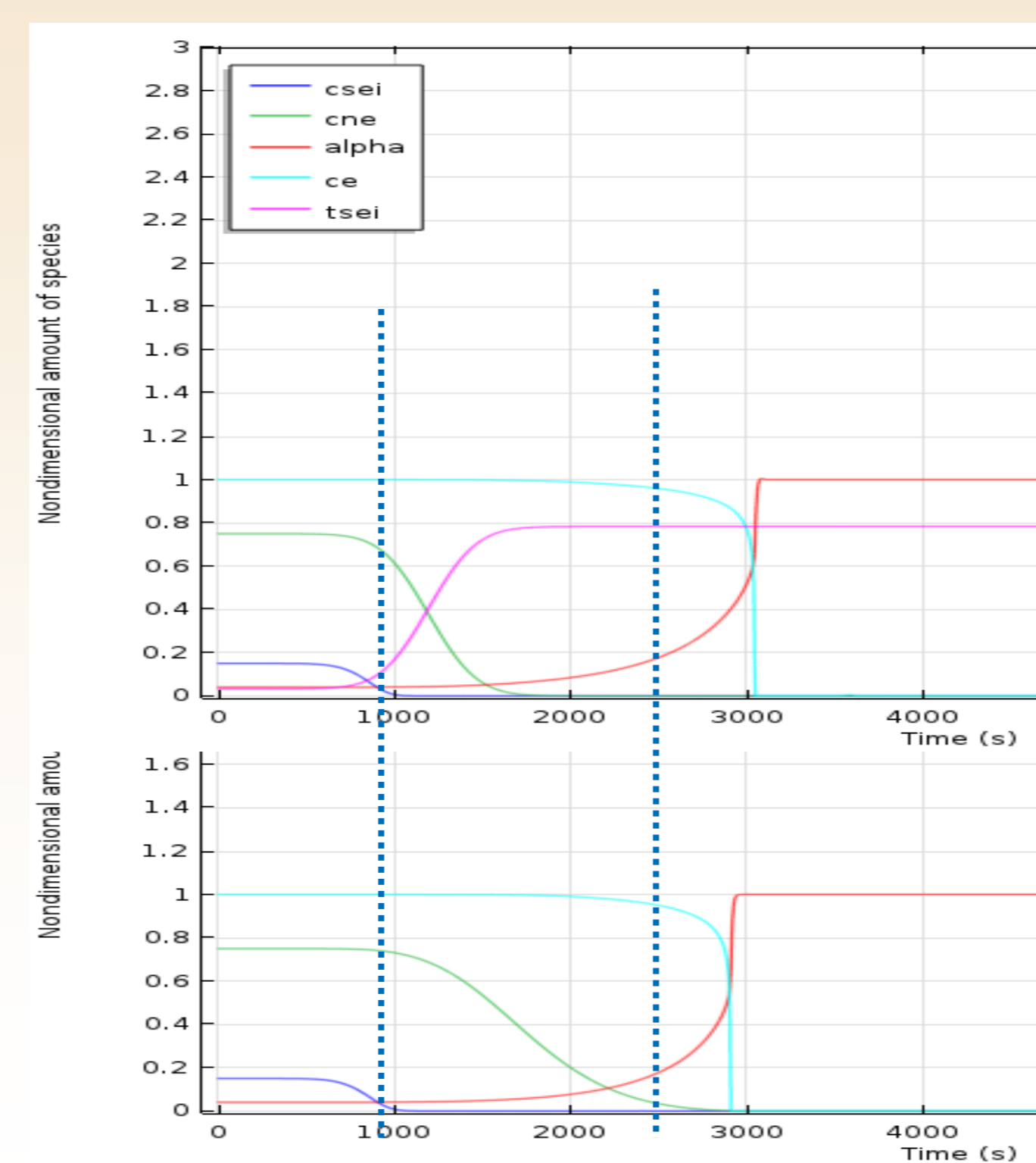
RESULTS

- Evidence of 3 key temperatures on BTC tests for all cells:
 - T₁ : First exothermal reaction / end of safe phase
 - T₂ : Fusion of the separator
 - T₃ : Thermal runaway

- Stade3 "Accelerating TR"
- Stade2 "Self heating"
- Stade1 "Safe"



- Using of modeling to further discuss the experiments:
 - First exothermal reaction posponed in aged cells
 - Passivation effect of the SEI layer formed during aging
 - The second degradation reaction is slower



Fresh A123s cell

Aged A123s cell (30% capacity fade)

CONCLUSIONS AND PERSPECTIVES

- An original experimental/modeling approach was developed to understand the effect of aging on Li-ion batteries safety
- the coupled thermal runaway model was validated at the cell level on BTC tests at INERIS testing platform
- the validated model was used in order to discuss why aged cells appear safer than fresh ones
- Further work has to be done to take into account cycling aging:
 - Study of safety degradation linked to cycling aging (Li plating...)
 - Study of high energy cells with up-to-date Li-ion technologies

[1] S. Abada et al., "Safety focused modeling of lithium-ion batteries: A review," *J. Power Sources*, vol. 306, pp. 178–192, 2016.

