Li-ion Battery Aging

MATHEMATICAL MODELING FOR DIAGNOSTIC PROCESSES

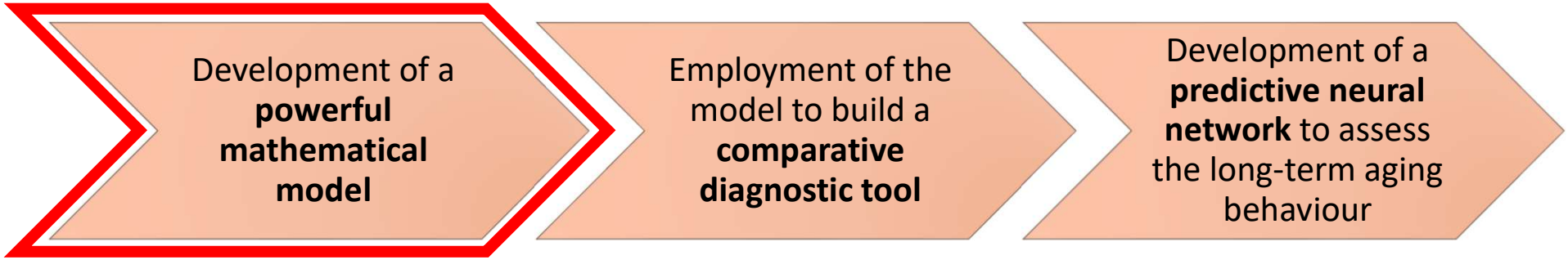
&

ONLINE SOH MONITORING IN INDUSTRIAL VEHICLES

Fabio Rossi – Photovoltaic Lab

Cyle aging model and predictive neural network

Workflow


Development of a **powerful mathematical model**
Employment of the model to build a **comparative diagnostic tool**
Development of a **predictive neural network** to assess the long-term aging behaviour

Mathematical model

Models considered from literature:

Stretched exponential decay: mainly used for early-life stages [1]

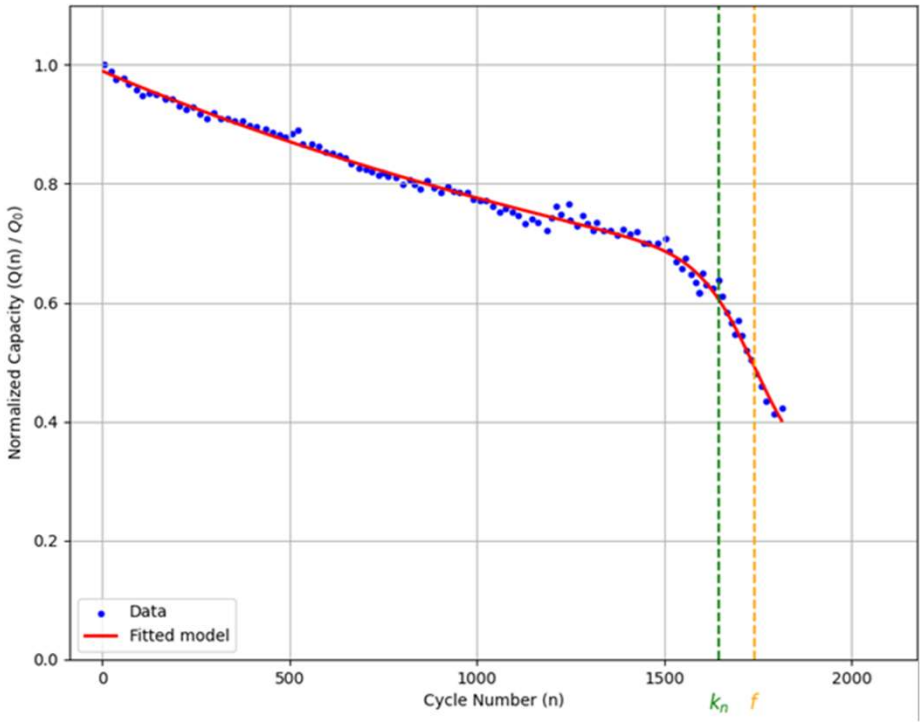
Sigmoidal decay: mainly used for late-life stages [2]

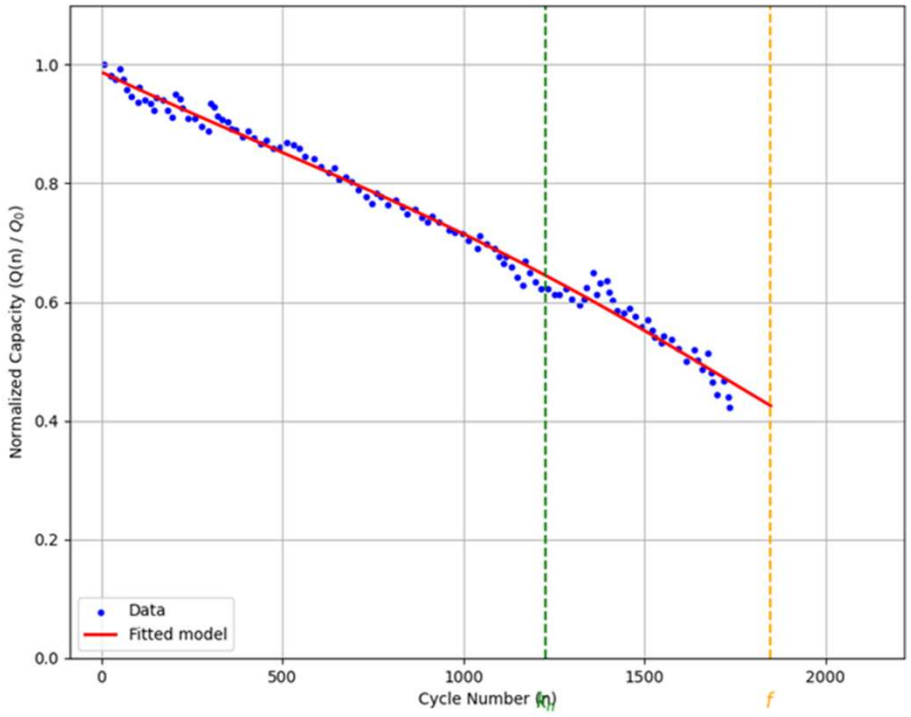
New model describing the whole life

[1] DOI: 10.1149/2.0611908jes

[2] DOI: 10.1016/j.est.2020.102011

Some fits on real data





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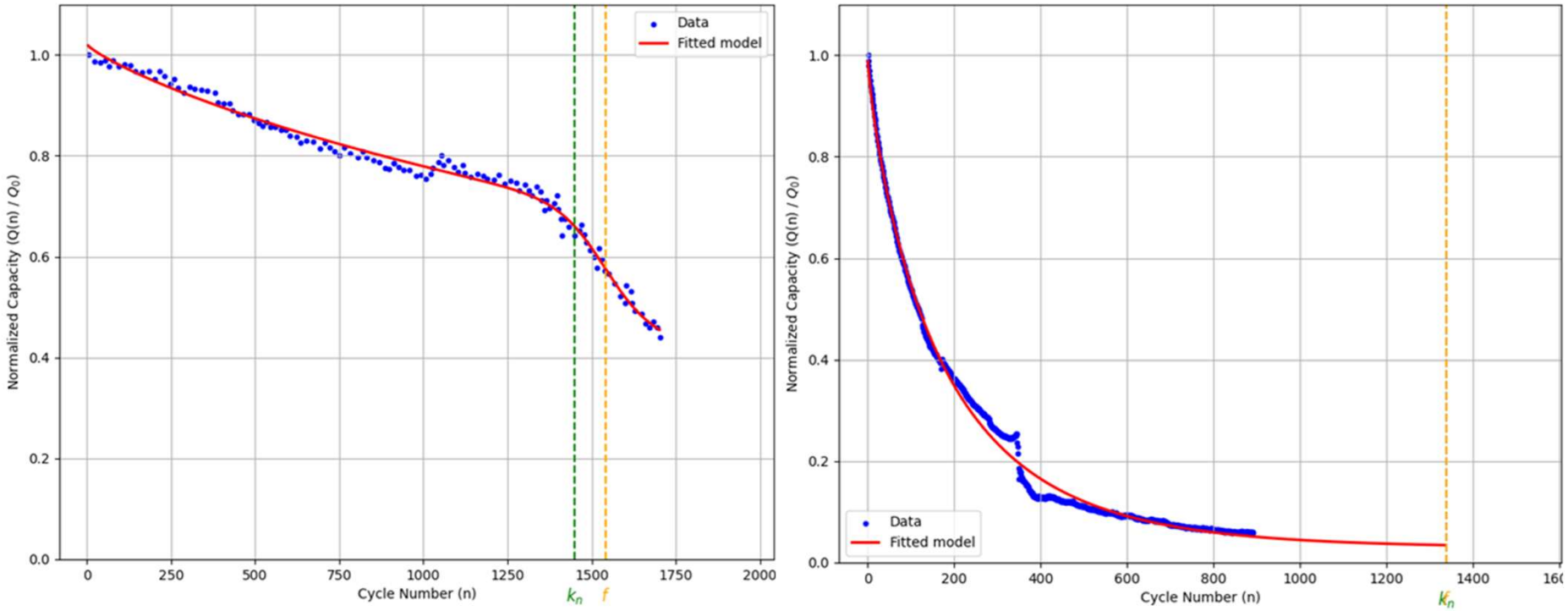

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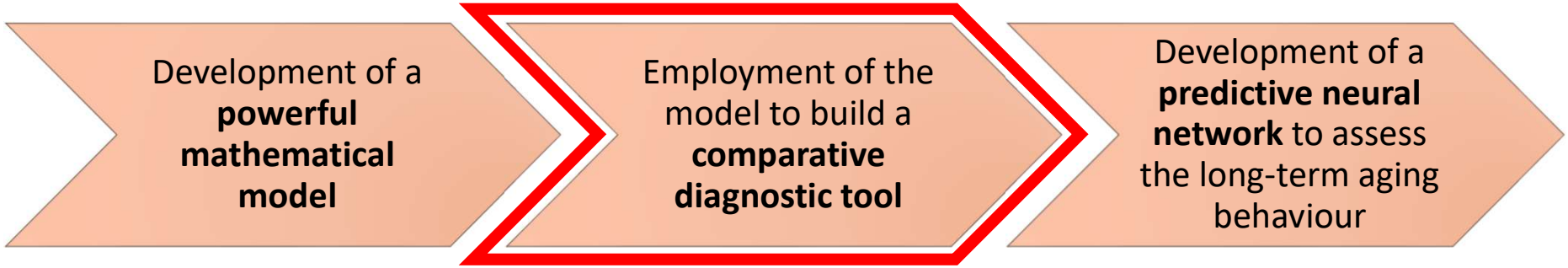
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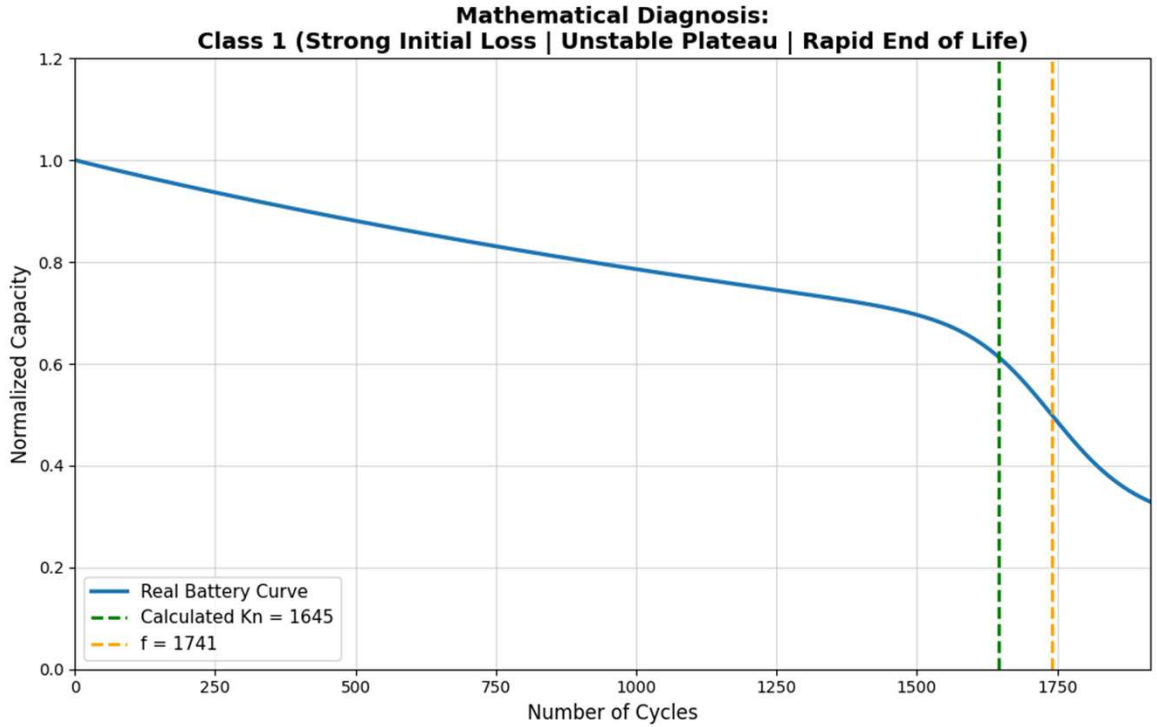
Diagnostic tool



--- MAIN METRICS ---

Pre-Plateau Lost Capacity:
100.0%

Plateau Duration:
0.0%

Capacity Drop in Plateau:
0.0%

L Value (end of life index):
1.06

--- PHASE DIAGNOSIS ---

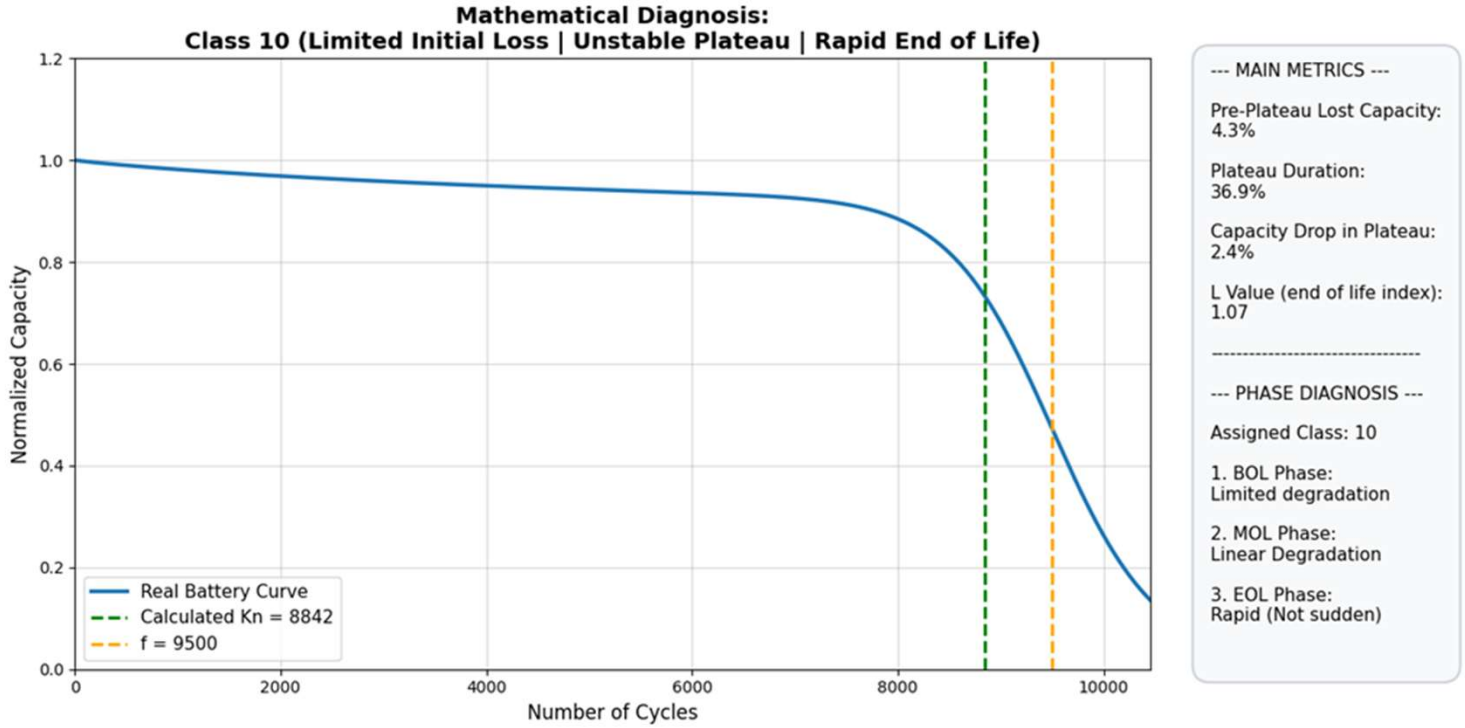
Assigned Class: 1

1. BOL Phase:
Pronounced degradation

2. MOL Phase:
Linear Degradation

3. EOL Phase:
Rapid (Not sudden)

Diagnostic tool



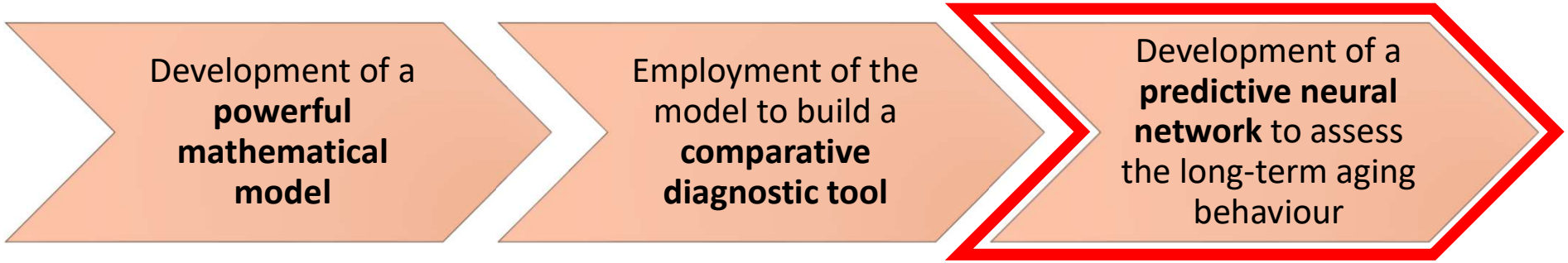
Diagnostic tool

Pros	Cons
Accurate diagnosis	Full life cycle test needed
Usable to assess the “fingerprint” of a given type of cell	Can’t predict anomalies in a single cell
Usable to compare different cells and optimize their choice in battery manufacturing	Requires prior characterization of every cell model

It can be used to develop an **online database** containing **aging data** from different kinds of **commercial cells**, sorted by manufacturer, chemistry, geometry etc.

Battery manufacturers will be able to chose the perfect cells for their purpose based on **the characteristic shape of the aging trajectory.**

Workflow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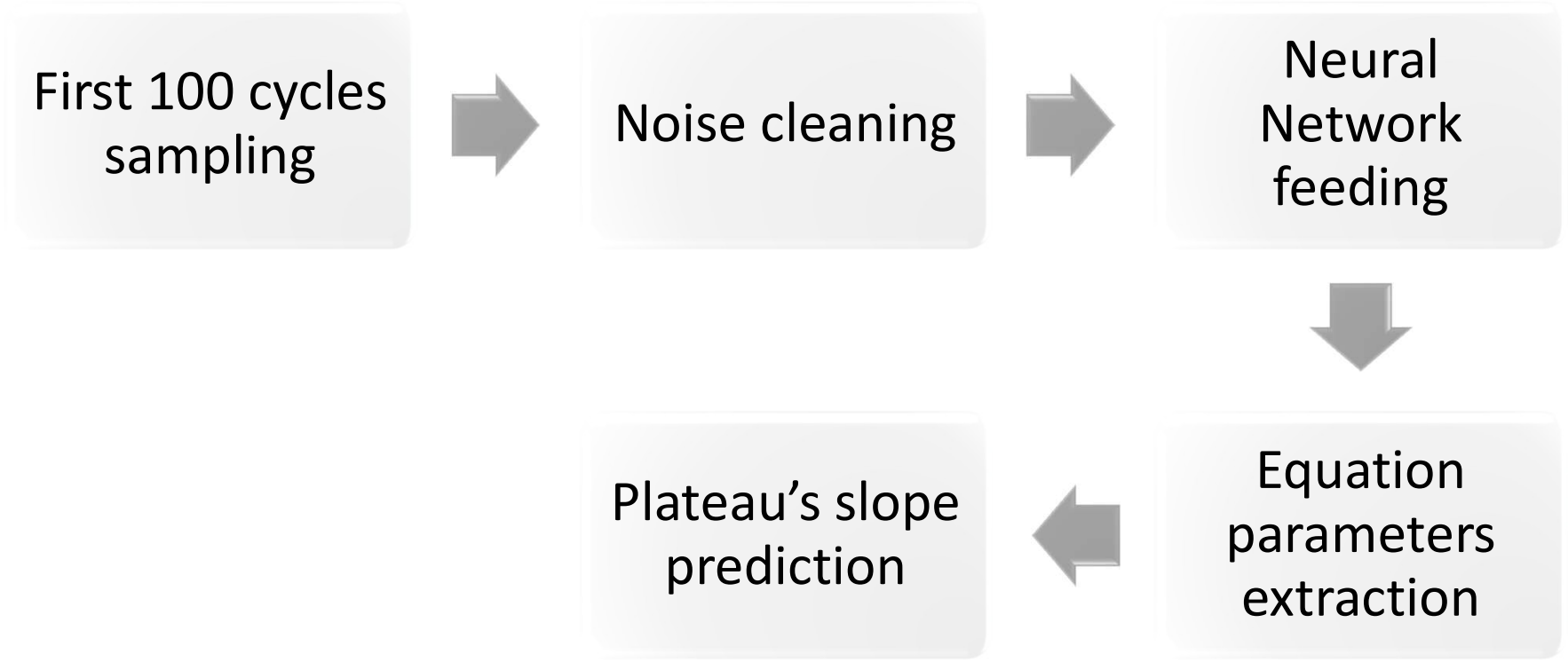
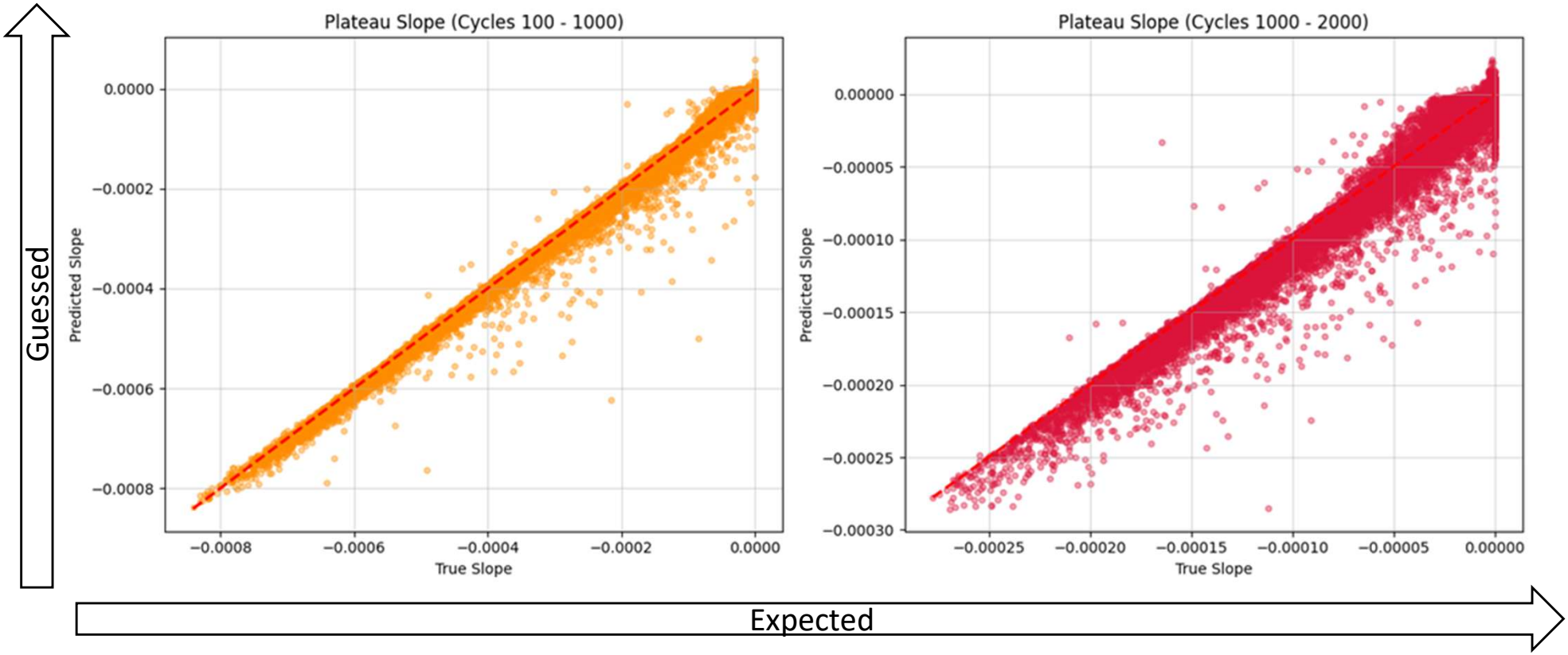
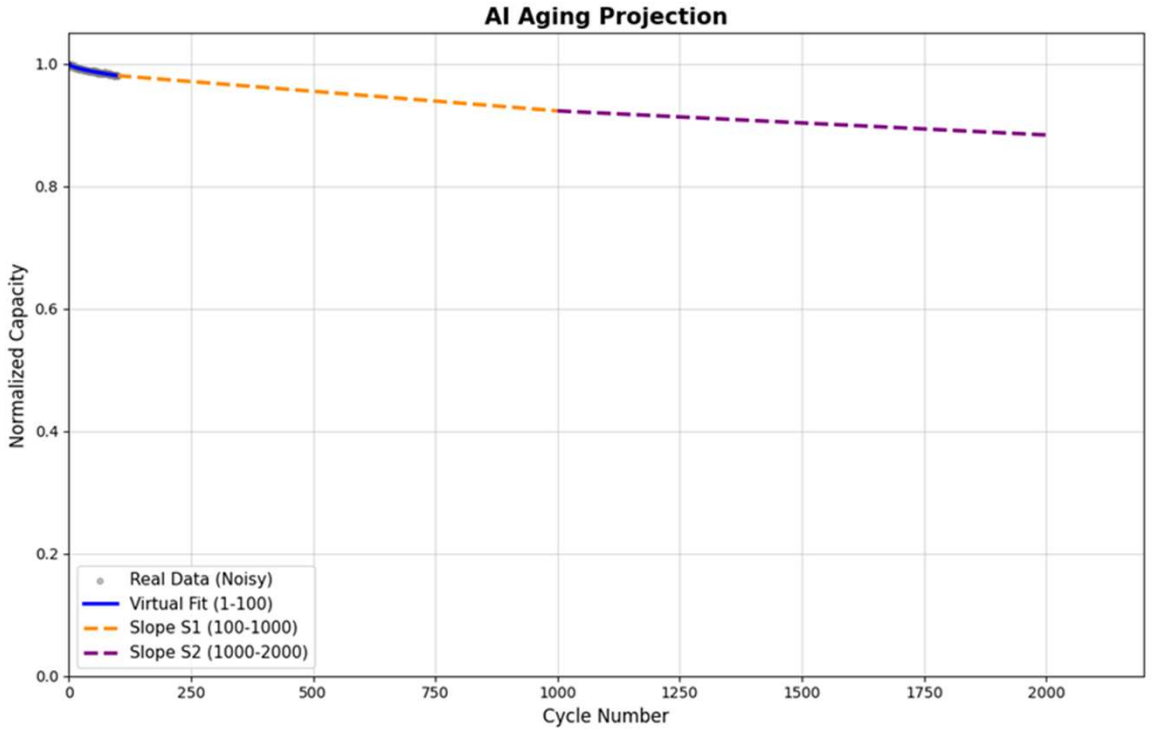
Predictive neural network



Predictive neural network



Predictive neural network



--- PLATEAU SLOPES ---

S1 (100-1K): -6.39e-05
S2 (1K-2K): -3.93e-05

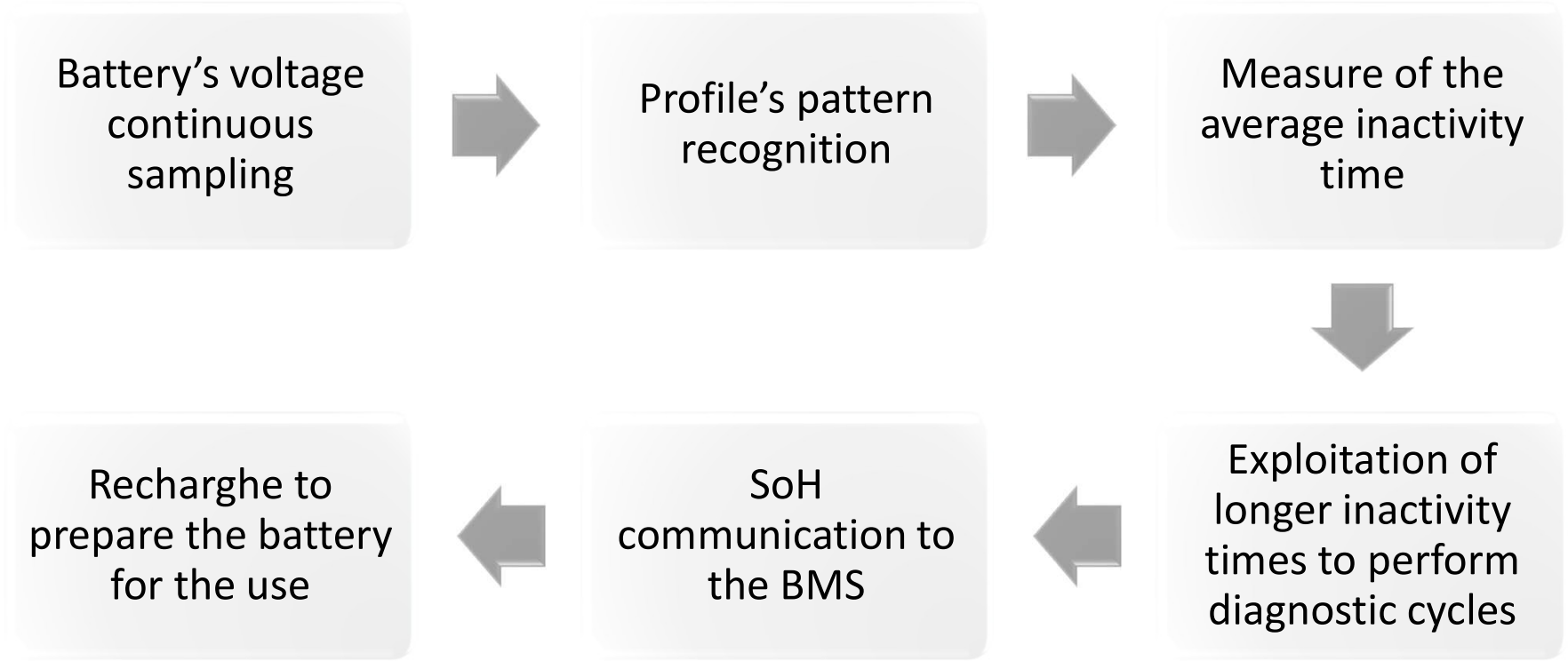
Online SoH monitoring in industrial vehicles

Aim of the work

In an industrial context an accurate measure of the state of health (SoH) of a vehicle's battery can prevent the waste of a battery that can still properly work.

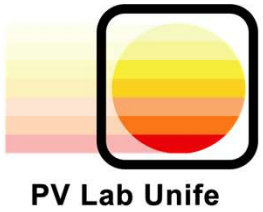
To maximize the accuracy in the online SoH measurement for industrial electric vehicles, the following algorithm was developed during the **ADVICE** Project, in collaboration with our partners **4E-Consulting** and **CRP Software.**

Algorithm outline



Main features

Pros	Cons
Highest accuracy capacity measure through coulomb counting	Long time required for the test
Smart exploitation of inactivity timeframes	Initial calibration period required to learn the profile
Prior battery characterization not required	Diagnosis frequency limited by the profile shape
Adaptive calibration in case of profile change	
Robust against usage history and temperature	



Thanks for the attention!