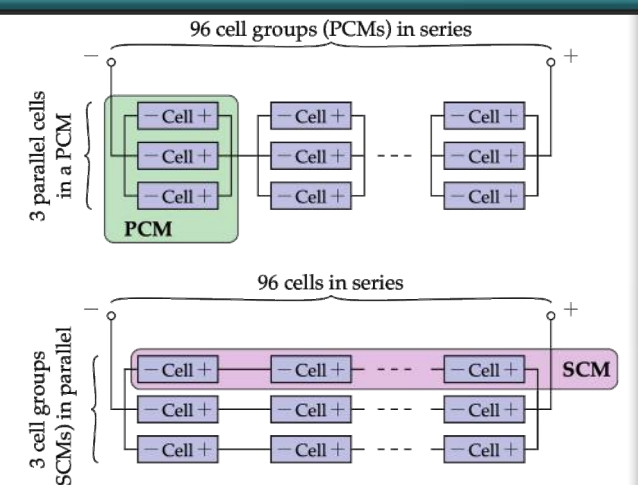


INTRODUCTION

- **Physics-based cell models can predict** internal cell electrochemical variables that determine onset of premature aging and failure
- We seek to **extend these models to describe operation of battery packs** comprising PCMs or SCMs to be able to explore more realistic scenarios
- This work is based on discrete-time physics-based reduced-order cell models that have **input = applied current** and **output = measured cell voltage**



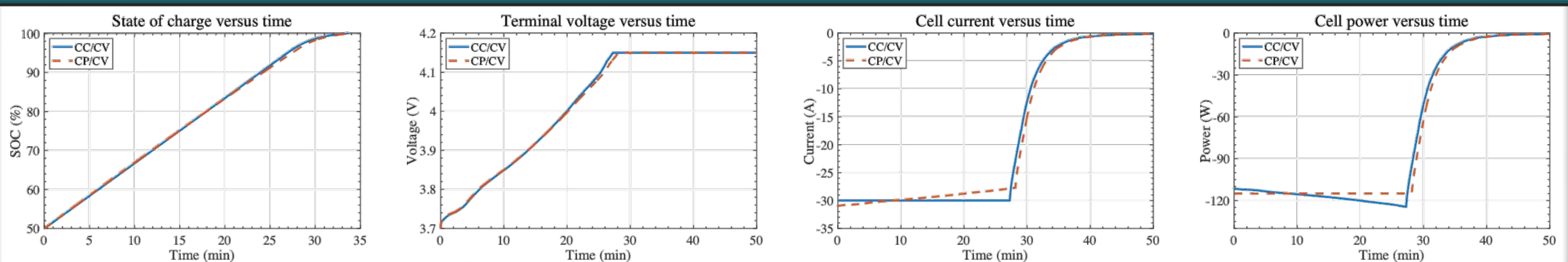
SIMULATING CONSTANT VOLTAGE AND POWER

- Can use this model to simulate CV or CP events by adjusting cell input current until calculated cell voltage or power equals the desired value
- This is done via a line-search optimization, which runs every time step to compute input current

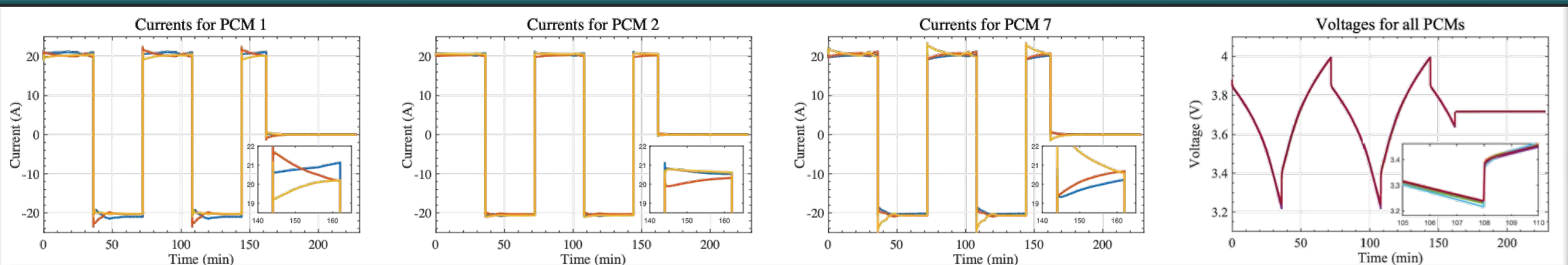
SIMULATING MULTICELL BATTERY PACKS

- Idea generalizes to simulating battery packs
- Optimize branch currents such that all branch currents sum to applied battery-pack current and such that cells wired in parallel have identical terminal voltage

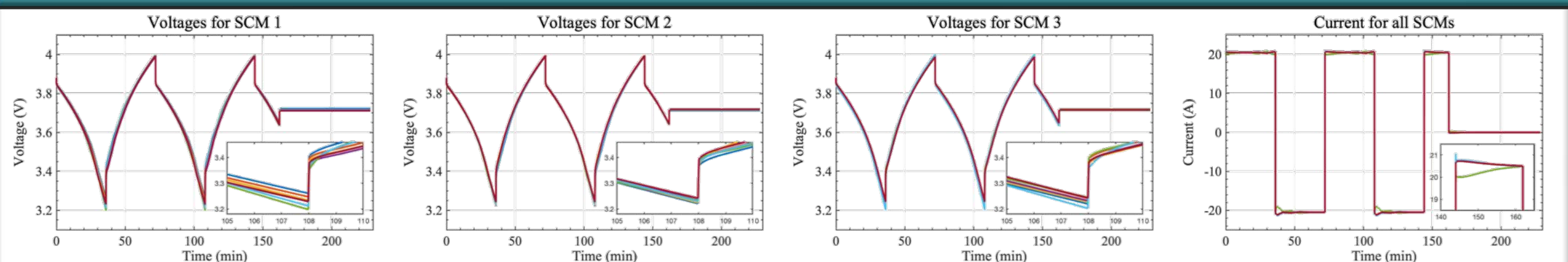
EXAMPLE: SINGLE-CELL CC/CV AND CP/CV CHARGING RESULTS



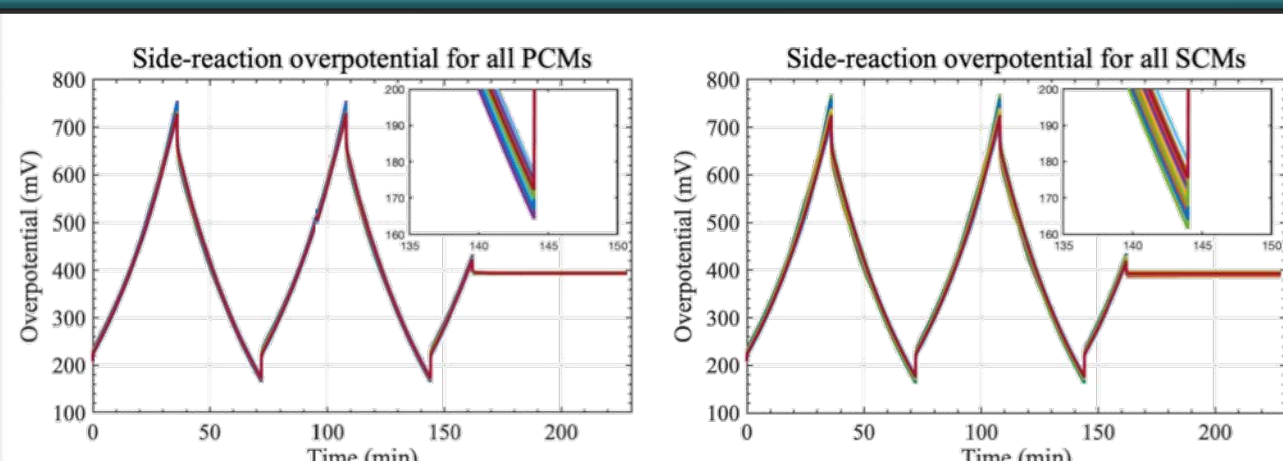
EXAMPLE: PCM SIMULATION RESULTS FOR 7S3P BATTERY PACK



EXAMPLE: SCM SIMULATION RESULTS FOR 7S3P BATTERY PACK



INTERNAL ELECTROCHEMICAL VARIABLES



SUMMARY

- Use of **simple optimization converts model** having input = applied current to **one having input = desired voltage or desired power**
- Enables simulating CC/CV and CP/CV charging
- **Enables simulating battery packs**, exposing internal electrochemical variables for evaluation