

# Comprehensive performance simulation of PEM fuel cells

## Mathematical model

- Two phase CFD: liquid and gas
- Multiphase mixture model:
 
$$\rho_m = s\rho_l + (1-s)\rho_g$$

$$\rho_m \mathbf{u}_m = \rho_l \mathbf{u}_l + \rho_g \mathbf{u}_g$$

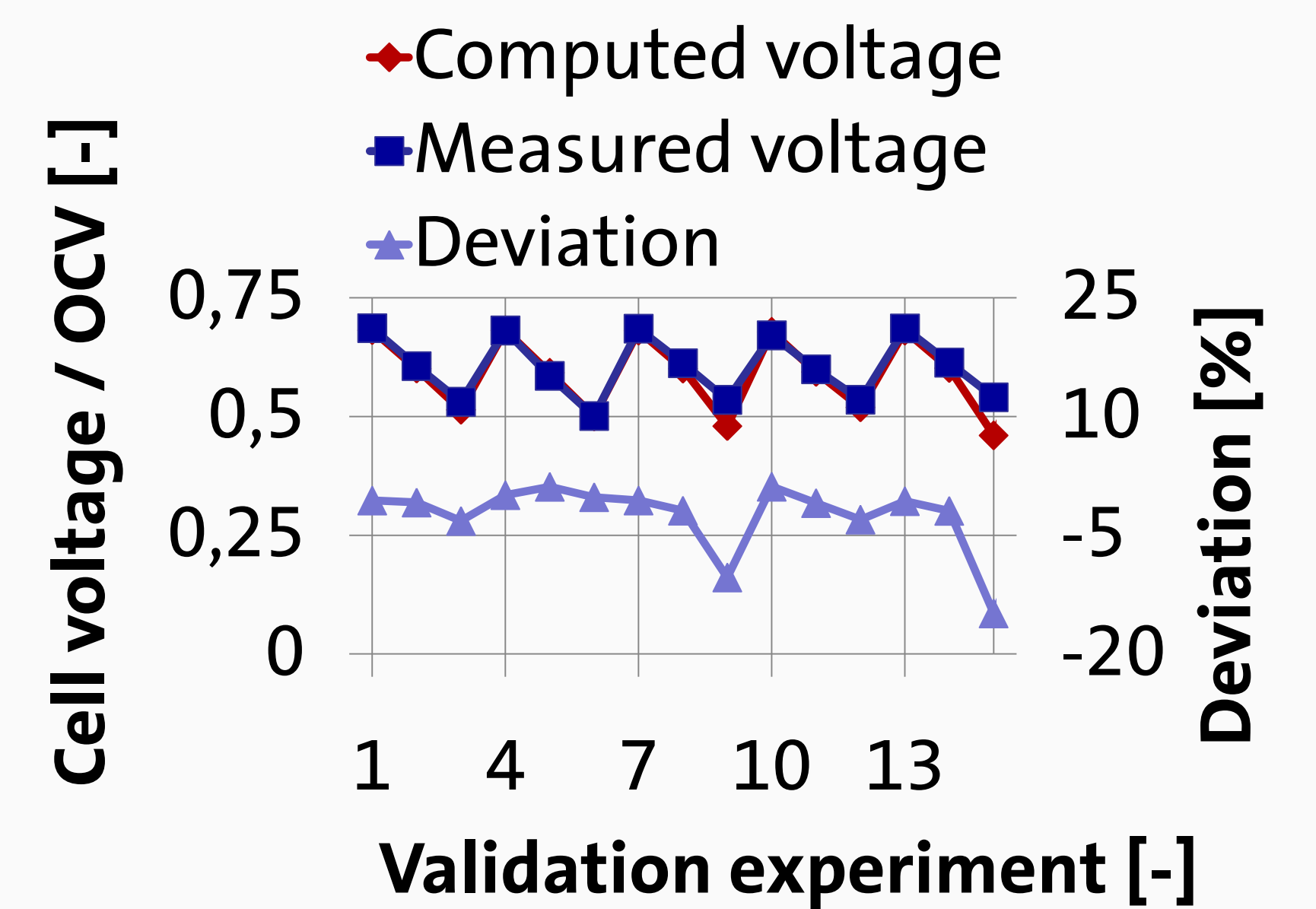
$s$ : liquid saturation       $l$ : liquid phase  
 $\rho$ : density                       $g$ : gas phase  
 $\mathbf{u}$ : velocity                       $m$ : mixture
- Conservation equations for mass, charge, momentum, species, and temperature
- Geometrically resolve all components

## Simulation setup

- Membrane: Aquivion (Solvay Solexis)
- Catalyst layers: DECODE specific (CEA)
- Diffusion media: 25BC (Substrate and MPL, SGL)
- Bipolar plates: SS316L (DANA)
- Data sources: DECODE partners, Literature
- Ambient pressure: 101.3 kPa

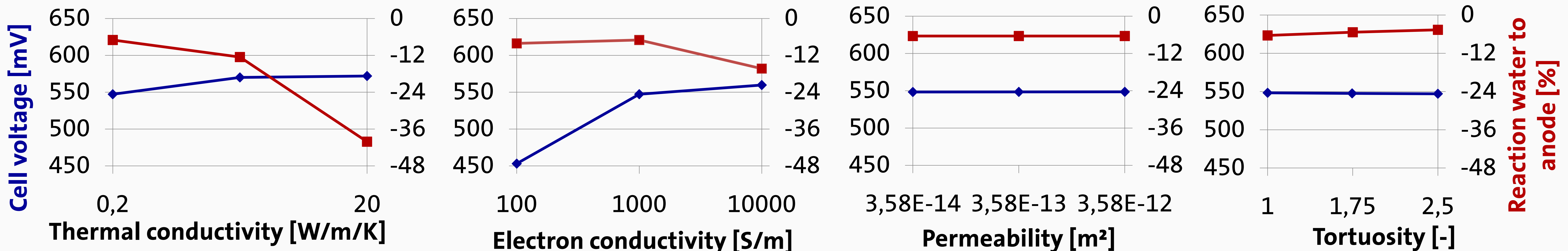
- 15 Validation experiments (done at GM FCA, Rochester, NY, USA)

- Case 1-3: Counter flow, dry conditions, varying current densities, varying temperatures
- Cases 4-6: Like 1-3 but co-flow
- Cases 7-15: Varying inlet relative humidities at anode and cathode



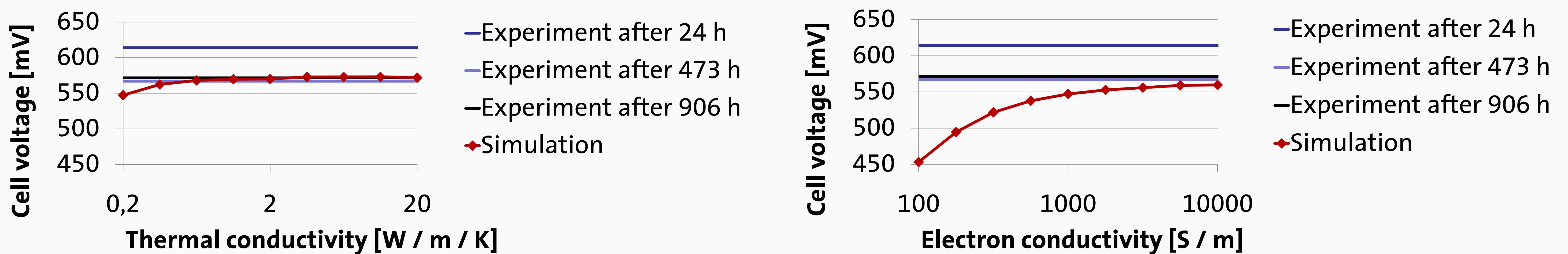
- Operating temperature: 60 °C
- Current density: 0.6 A / cm<sup>2</sup>
- Stoichiometry: 1.5 (anode), 2.0 (cathode)
- Inlet rel. humidity: 42 % (anode), 66 % (cathode)
- Varying values for electron conductivity, thermal conductivity, permeability, and tortuosity in the diffusion media

## Most sensitive parameters in GDL: thermal and electron conductivity



## Simulation vs. experiment - parameter variation in GDL

- Experiments done at DANA, Neu-Ulm, Germany



## Conclusions for present operating conditions

- Most sensitive parameters: 1. electron conductivity, 2. thermal conductivity
- Exact agreement of simulation and experiment for degraded cells
- Next: Why are simulation results closer to degraded cells than to new cells? Parameter sensitivity in other components?

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2<sup>nd</sup> CARISMA International Conference  
La Grande Motte, France  
19 – 22 September 2010

This work has been performed within the European project DECODE.

The financial support of the 7th Framework Program (Grant Agreement 213295) is gratefully acknowledged.

