FROM RESEARCH TO INDUSTRY

cea tech

Grenoble INP
ÉCOLE DOCTORALE I-MEP2

ADEME
Agence de l'Environnement et de la Maîtrise de l'Energie

Isec

THREE-DIMENSIONAL MODEL OF A NEW THIN-PLATE LEAD-ACID BATTERY

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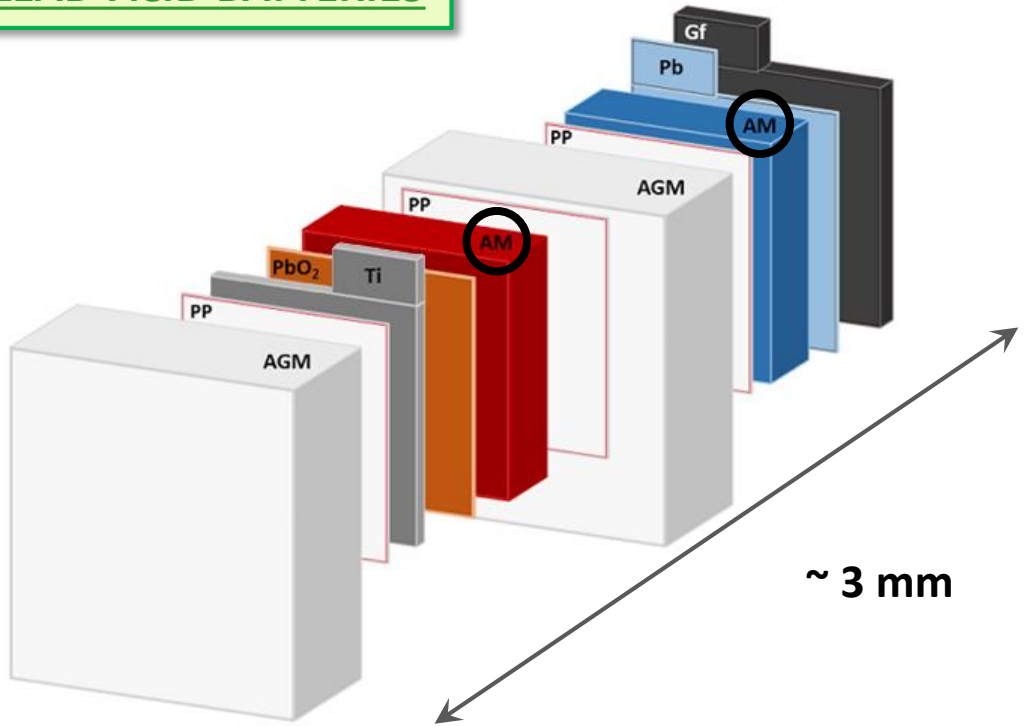
(with M. Cugnet & A. Kirchev)

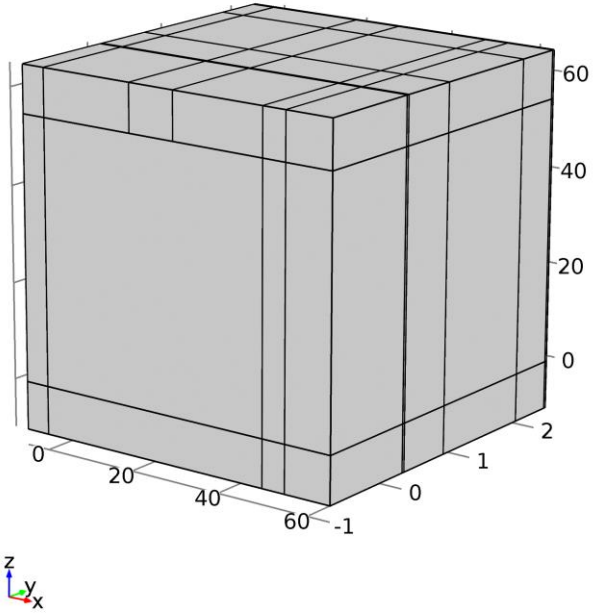
ines
INSTITUT NATIONAL
DE L'ENERGIE SOLAIRE

COMSOL CONFERENCE
2015 GRENOBLE

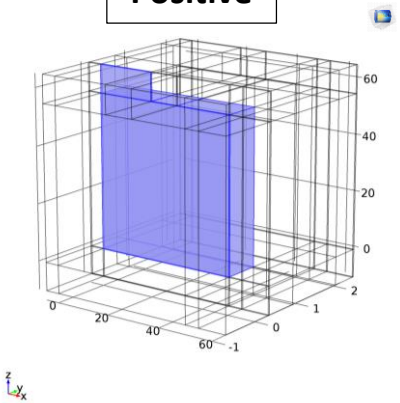
THIN-PLATE TECHNOLOGY FOR LEAD-ACID BATTERIES



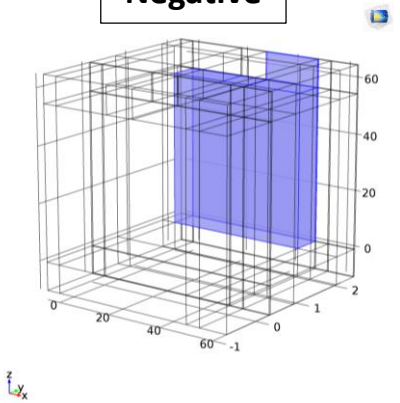
MODELISATION : GEOMETRY



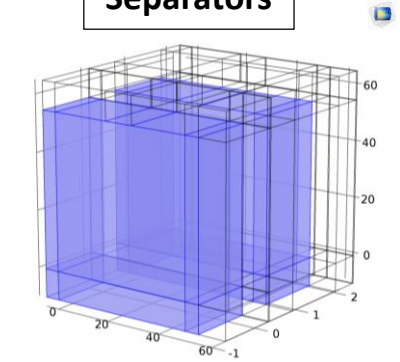
Positive



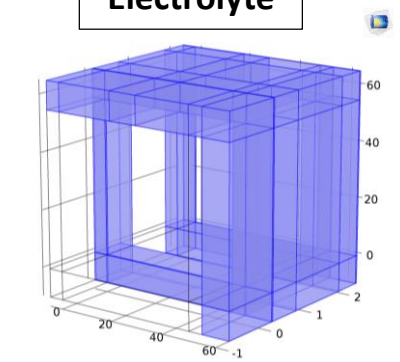
Negative



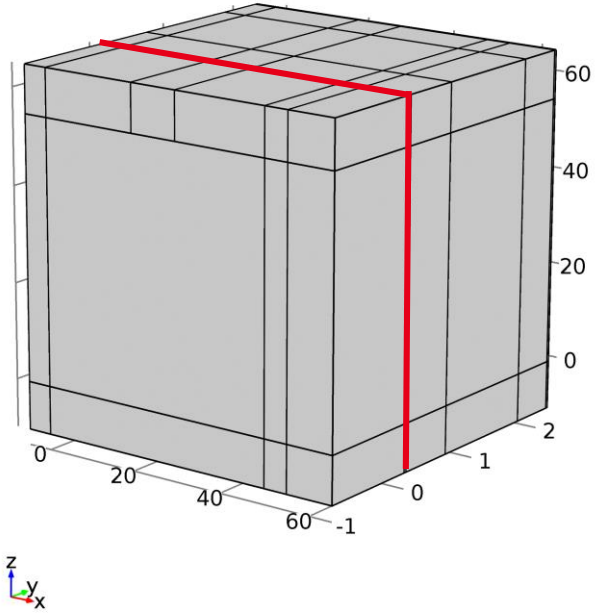
Separators



Electrolyte

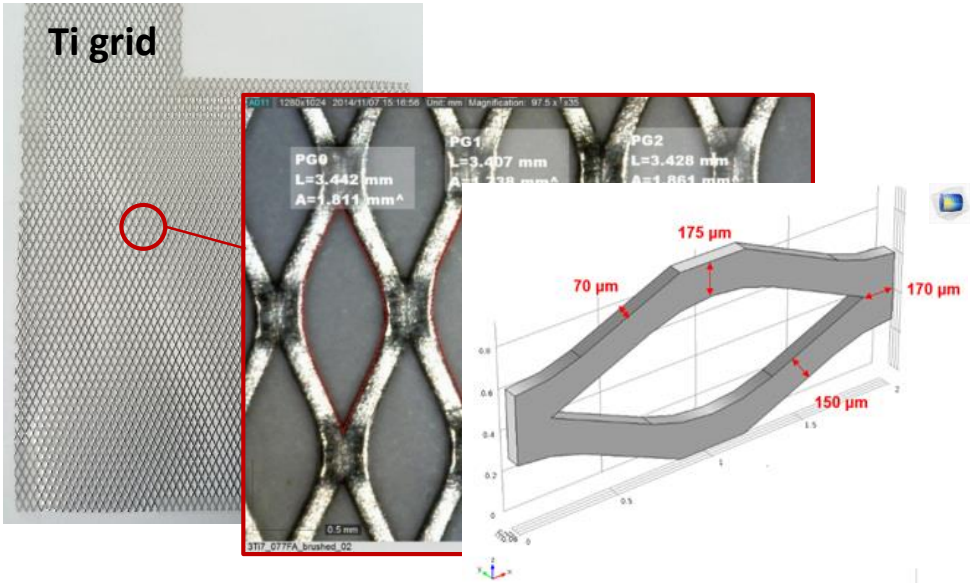


MODELISATION : HYPOTHESIS



84 domains

- Hypothesis : remove collectors (ex : positive)
  - <u>High</u> mesh cost
  - <u>Low</u> influence (at low rate)



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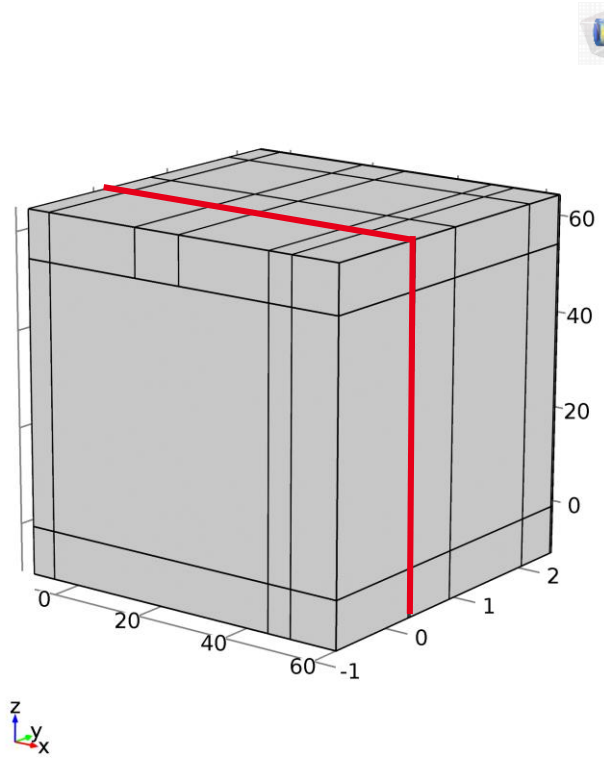

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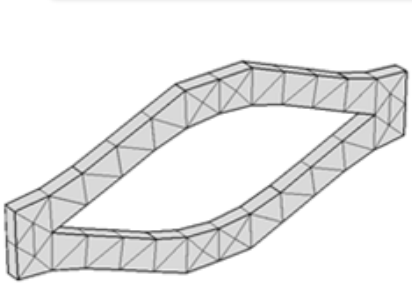
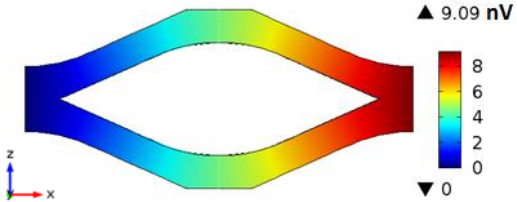


64 elements/◆

x 1 495

95680 elements

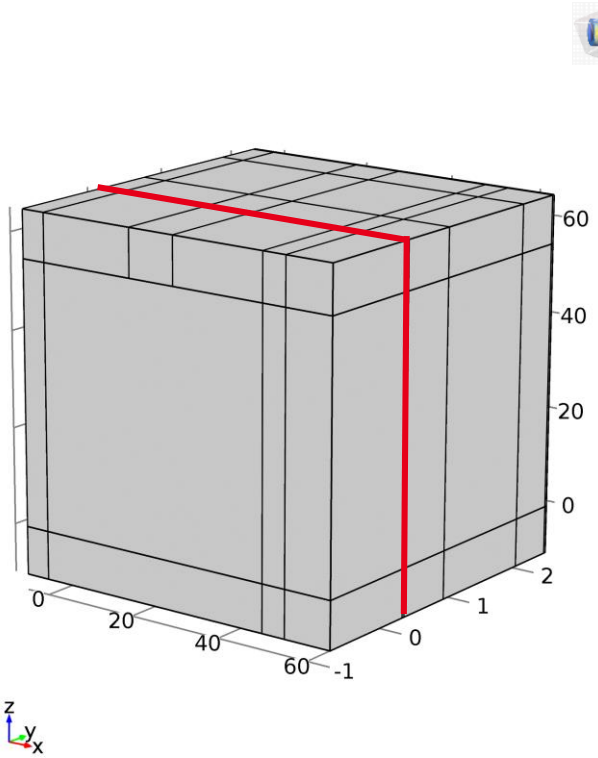
J = 10,7 A.m^{-2}



***Collector* :**

Ohmic Loss ≅ mV

MODELISATION : HYPOTHESIS



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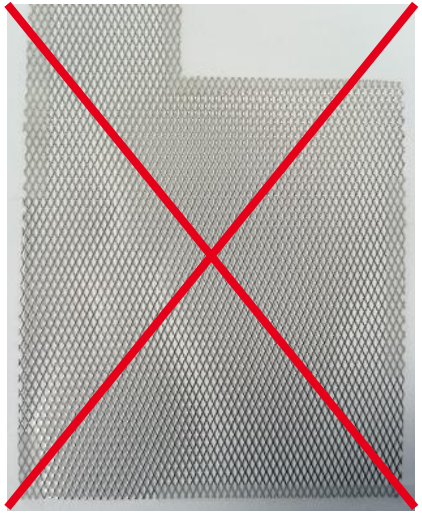
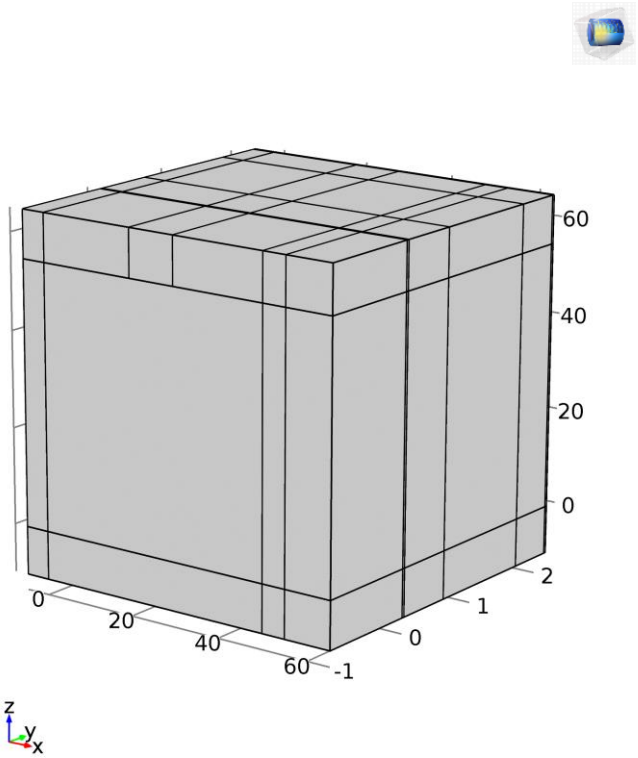


MODELISATION : PHYSICS



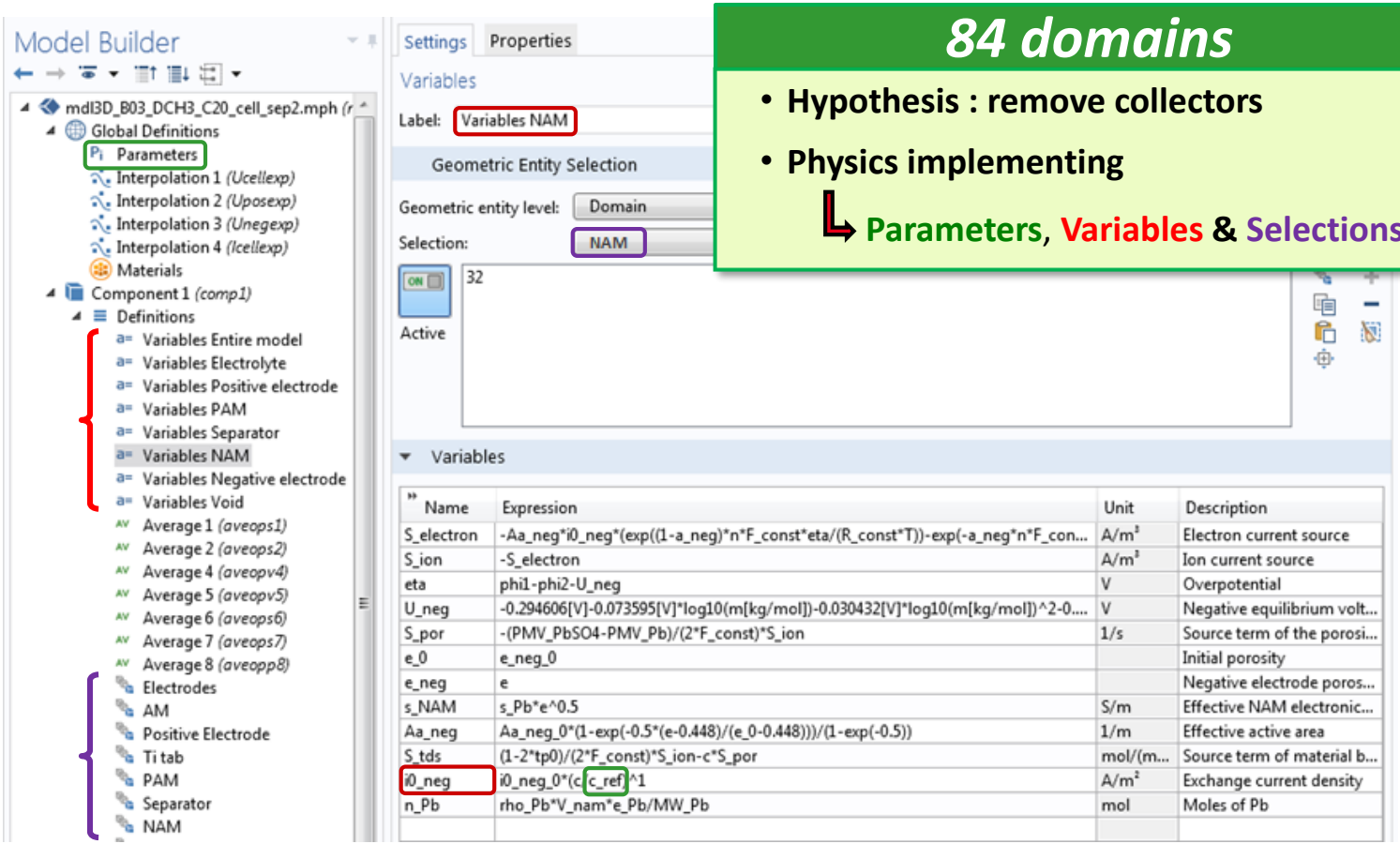
84 domains

- Hypothesis : remove collectors (ex : positive)
- Physics implementing
  - Ohm's law (solid (1)/liquid)
  - Porosity (2)
  - Material balance

$$(1)\ i_{soln} - \epsilon_a^{exm}\sigma\frac{\delta\varphi_{solid}}{\delta x} - I = 0$$

$$(2)\ \frac{\partial\epsilon}{\partial t} - \frac{\delta i_{soln}}{\delta x}\frac{1}{nF}\left(\bar{V}_a s_{a,e} + \bar{V}_b s_{b,e}\right) + \frac{R_{b,e}}{s_{b,s}}\left(\bar{V}_a s_{a,s} + \bar{V}_b s_{b,s}\right) = 0$$

MODELISATION : PHYSICS

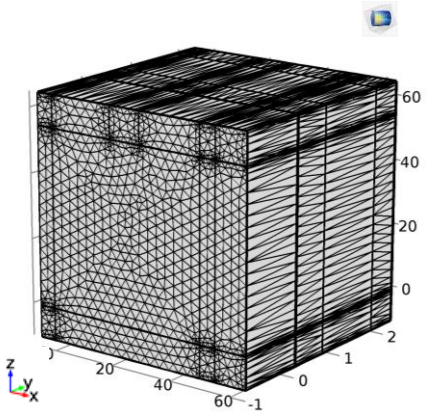


84 domains

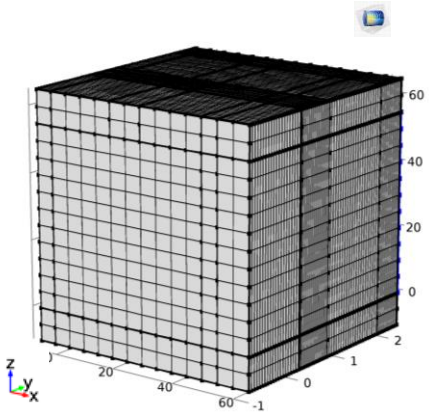
- Hypothesis : remove collectors
- Physics implementing

  ↳ Parameters, Variables & Selections

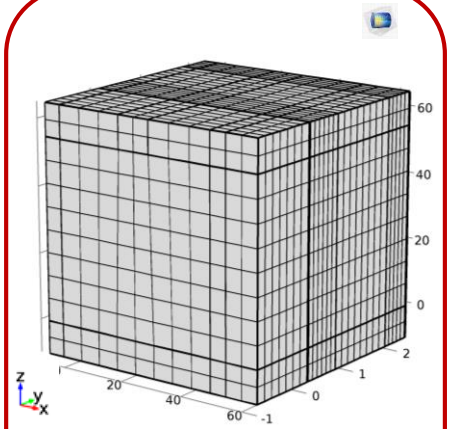
MODELISATION : MESH



Physics-controlled mesh
Coarser size
57 107 elements



User-controlled mesh
Mapped 1 & Distribution 1
13 860 elements
1h10min

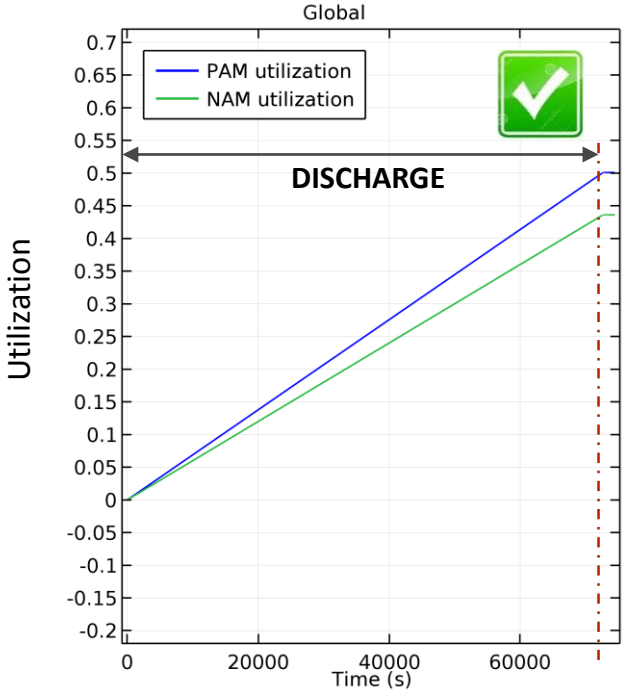


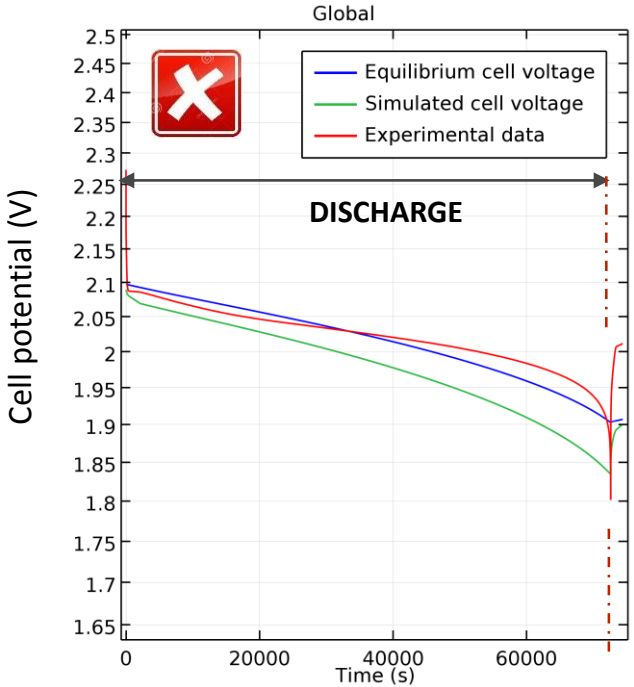
User-controlled mesh
Mapped 2 & Distribution 2
4 032 elements
15min

EFFICIENT MESH = TIME GAIN

- **User-controlled mesh**
- Mapped & Swept
- Distribution

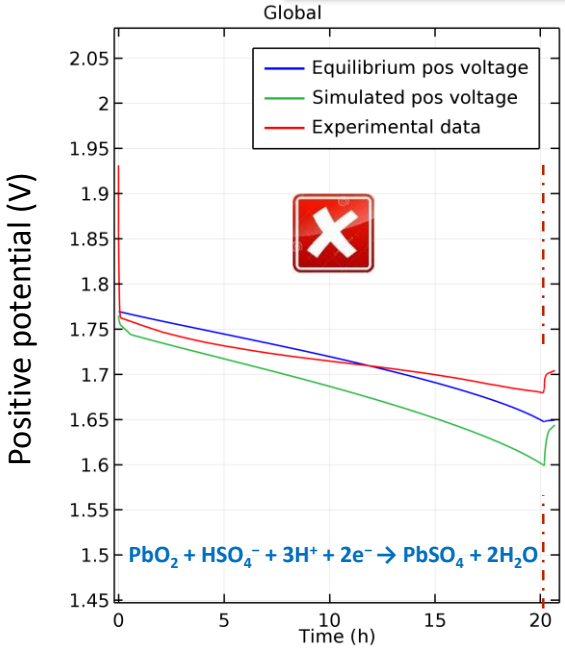
Discharge + rest : first results

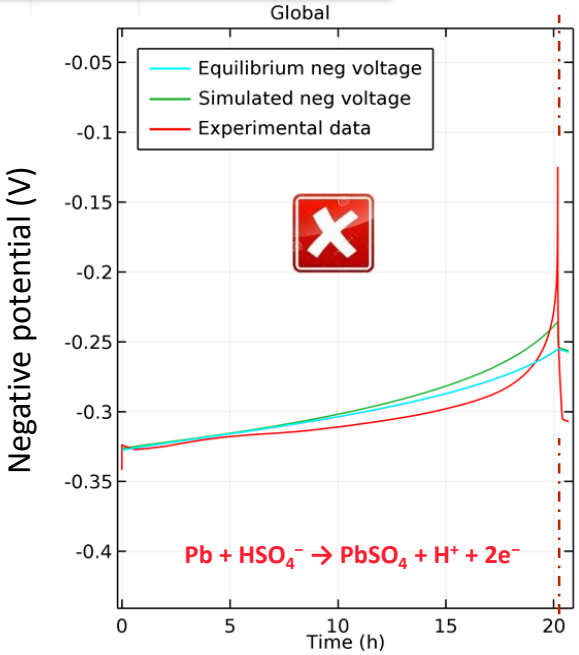




DISCHARGE : $PbO_2 + Pb + 2H_2SO_4^- \rightarrow 2PbSO_4 + 2H_2O$

Discharge + rest : first results

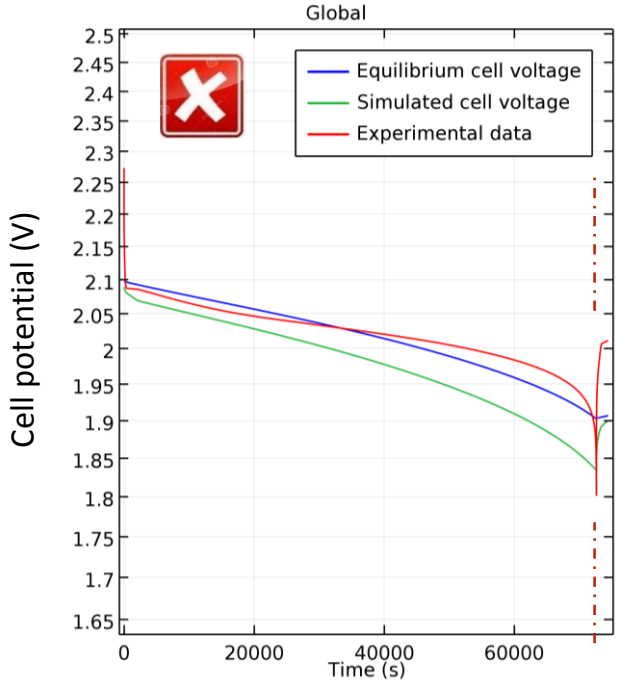


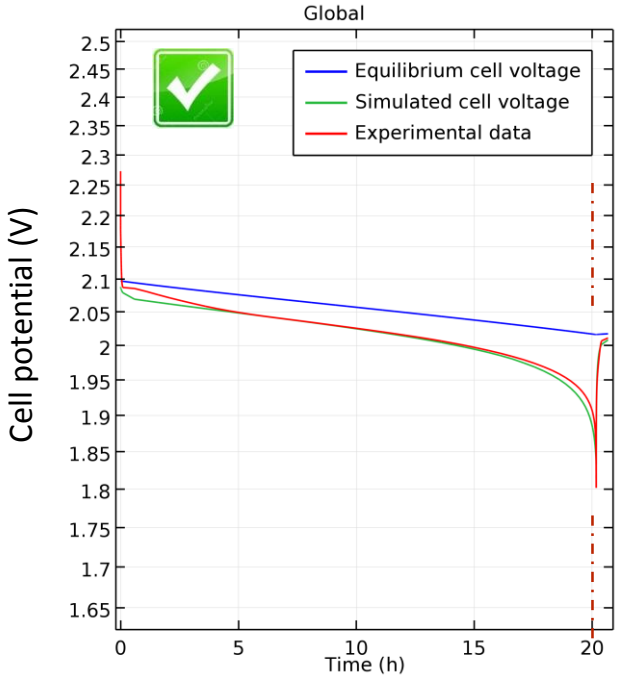


- **Lack of acid (+ & -)**
- **Inappropriate surface coverage (-)**

Adjustments

- PAM & NAM thicknesses / Porosity
- Electrolyte volume
- Coverage factor





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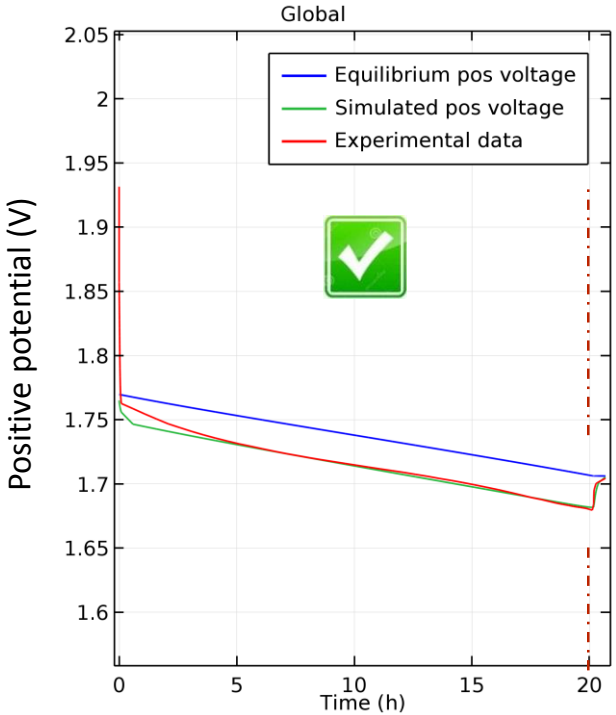
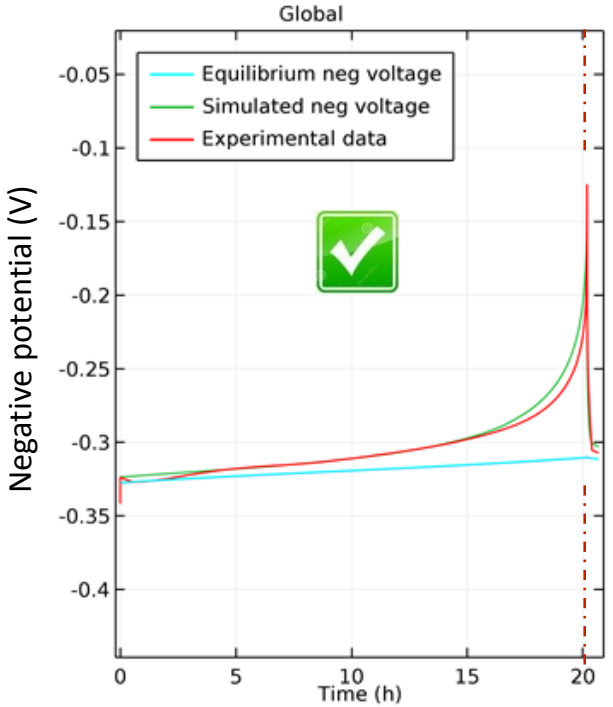
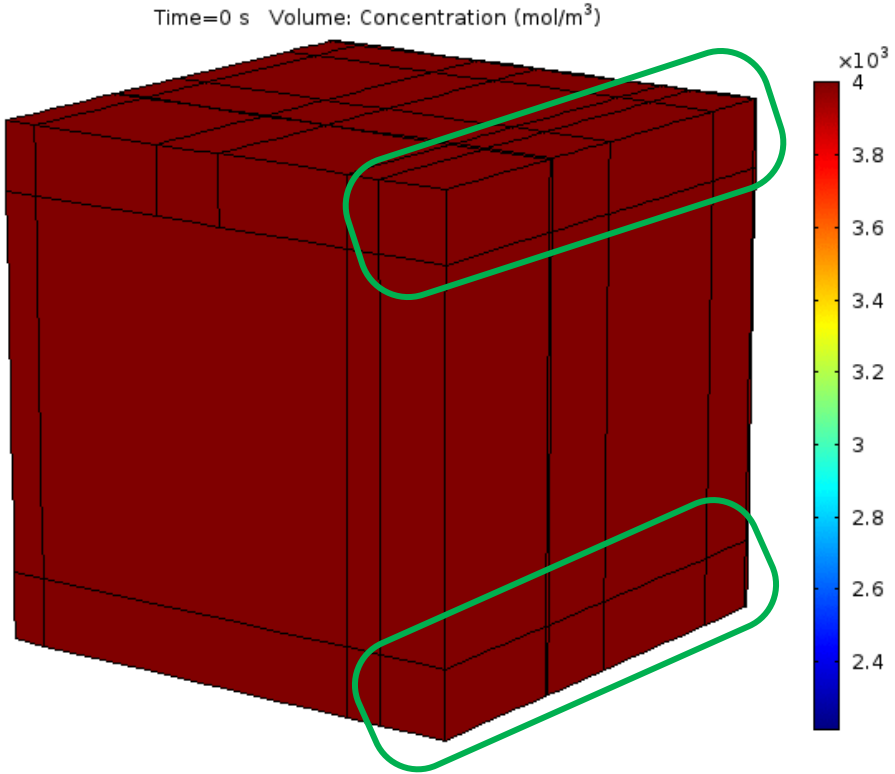




RESULTS



Acid concentration

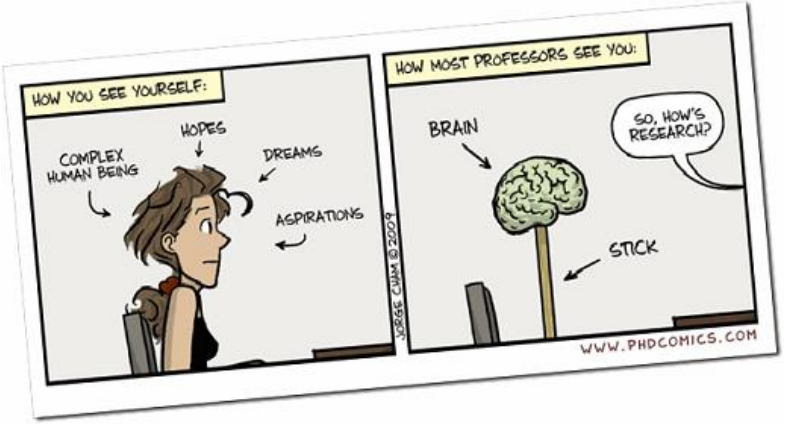
- **Heterogeneous consumption**
- **Critical volume**

Conclusions

- Importance of Hypothesis / Mesh / Parameters
- Determine precisely the key parameters :
  - AM thicknesses
  - Porosity
  - Exchange current etc
- Better understanding of the reaction (Acid consumption)

Perspectives

- Add Physics (heat transfer, nucleation and growth)
- Modelisation of Discharge at high rate
- Move to 2D ?



Thank you for your attention

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