

Impact of Using Selective Collector Bar Rodding on the MHD Stability of a 500 kA Aluminium Electrolysis Cell

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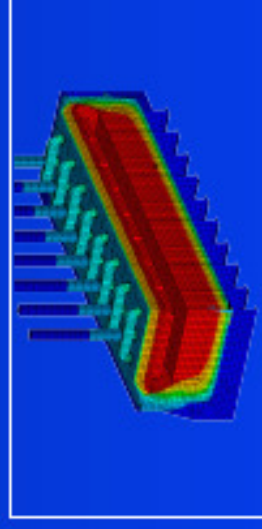
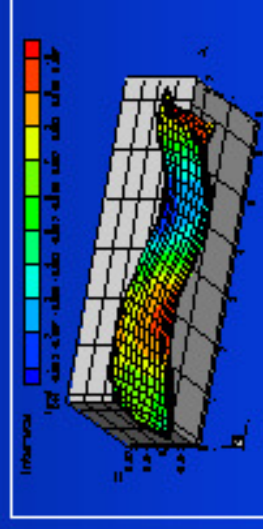
Plan of the Presentation

- Introduction
- Selective Rodding Pattern
- MHD Computational Model:
Electric Current Distribution
- MHD Modeling Results
 - Without Selective Rodding
 - With Selective Rodding
- Conclusions

Introduction

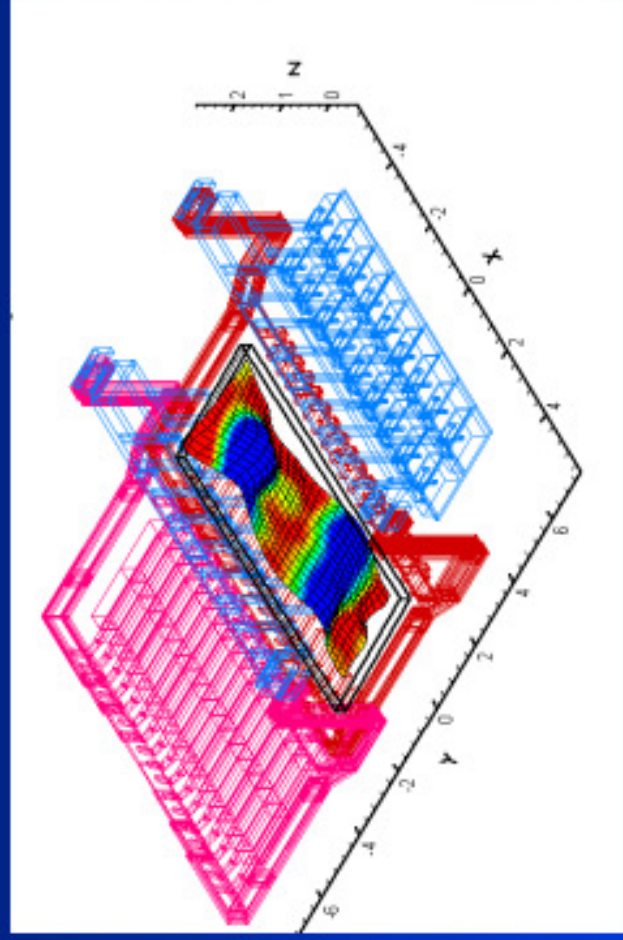
Currently, we can fit Hall-Héroult mathematical models into three broad categories:

- Stress models which are generally associated with cell shell deformation and cathode heaving issues.
- Magneto-hydro-dynamic (MHD) models which are generally associated with the problem of cell stability.
- Thermal-electric models which are generally associated with the problem of cell heat balance.



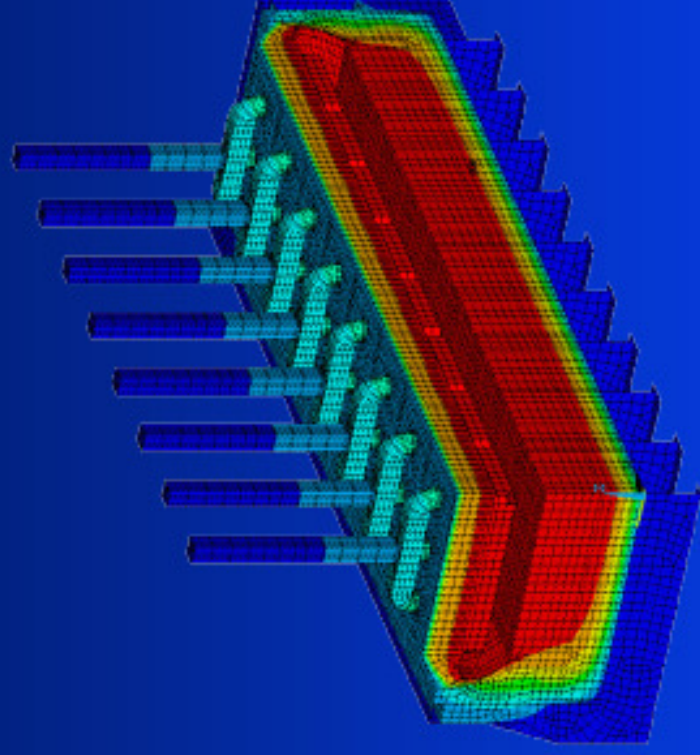
Cell
Design

Introduction



MHD Model:

centered around the liquid zone

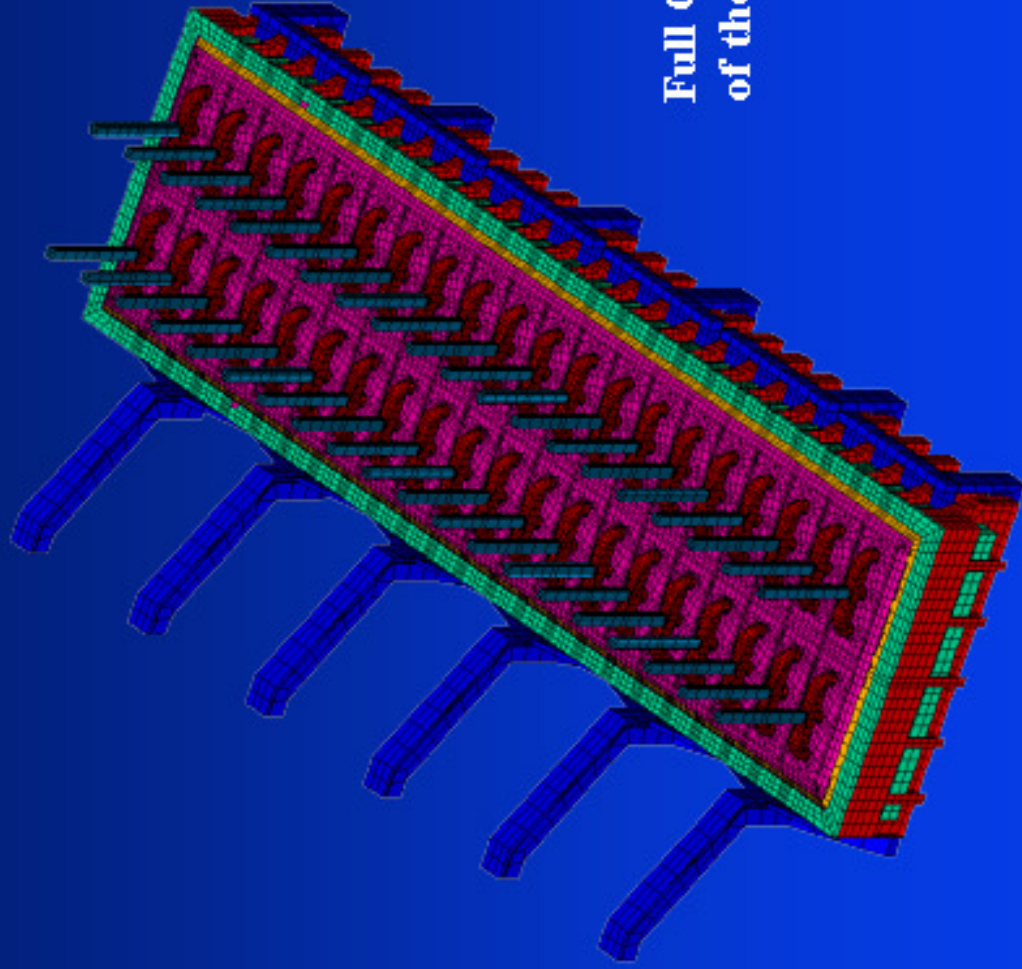


Thermo-Electric Model:

no need to include the liquid zone



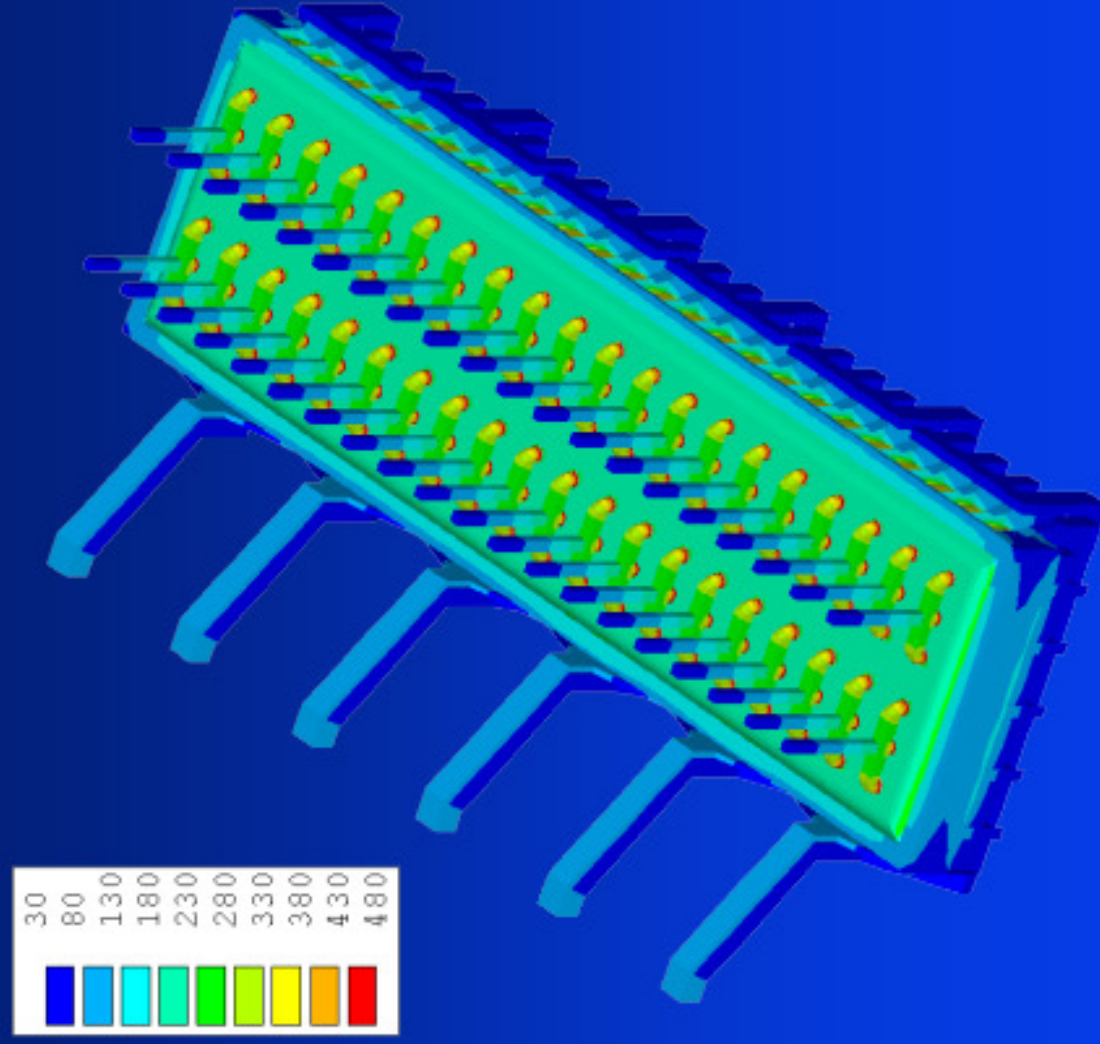
Introduction



Full Cell and Busbar T/E Model
of the 500 kA cell

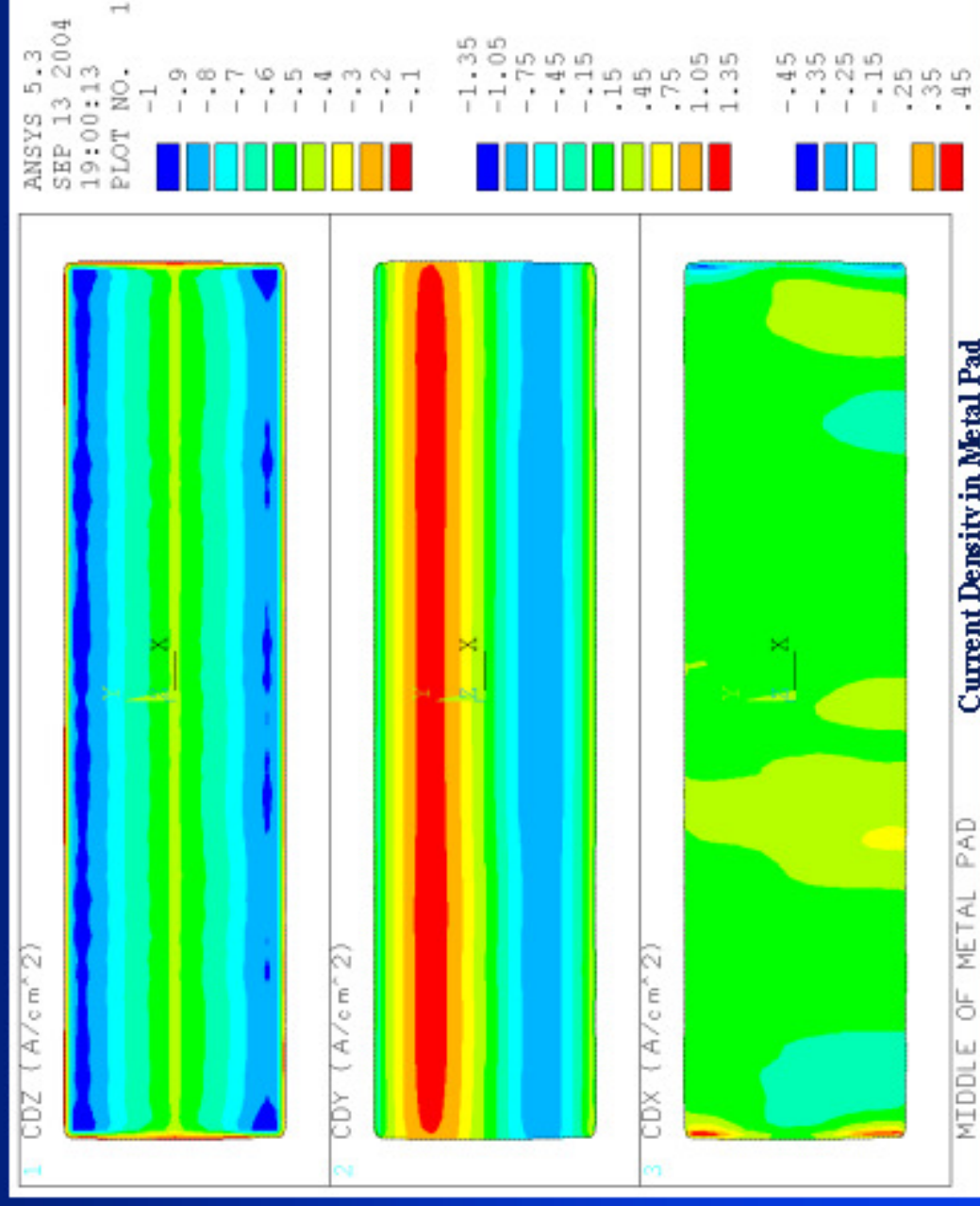


Introduction

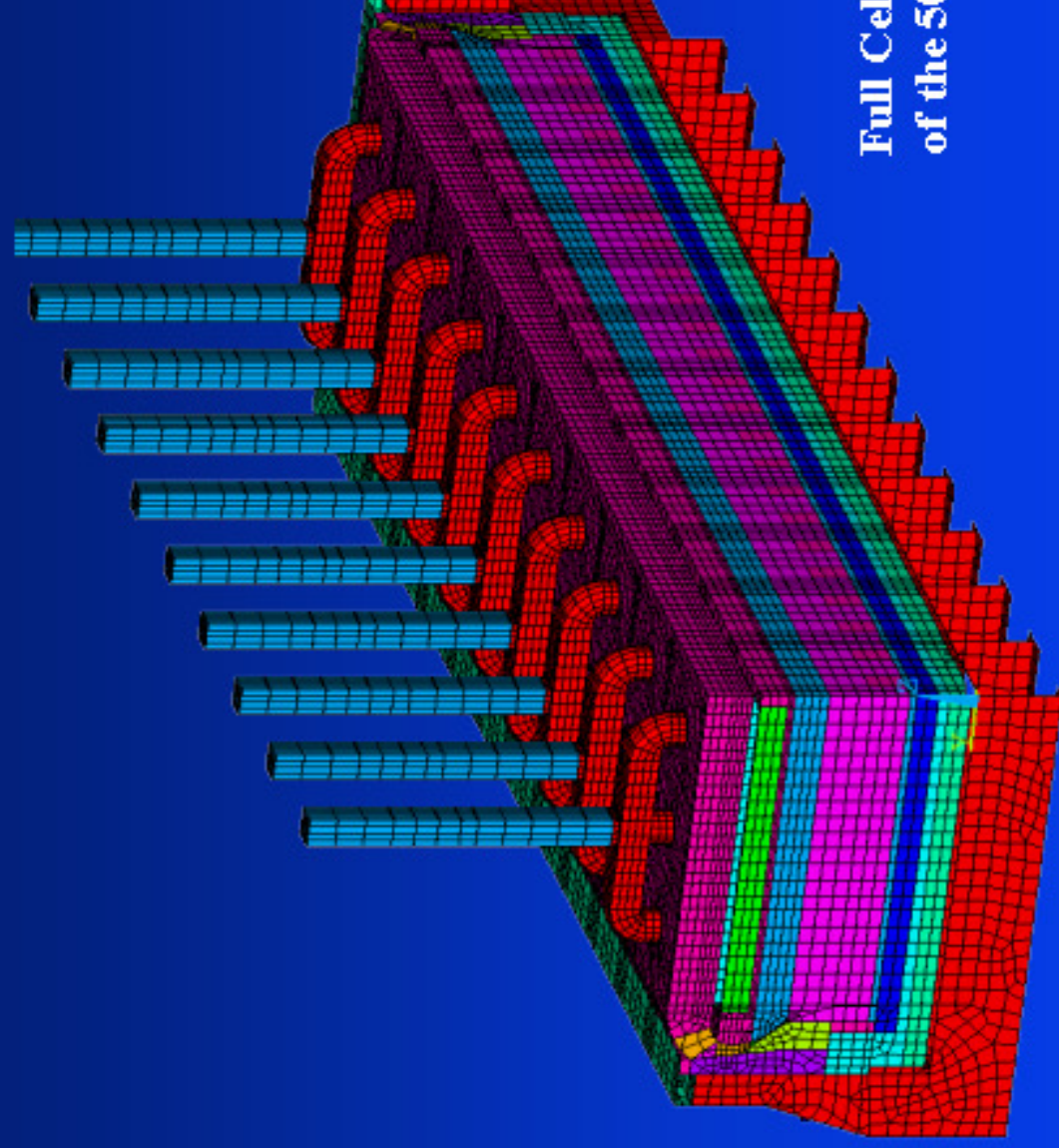


Isotherms

Introduction



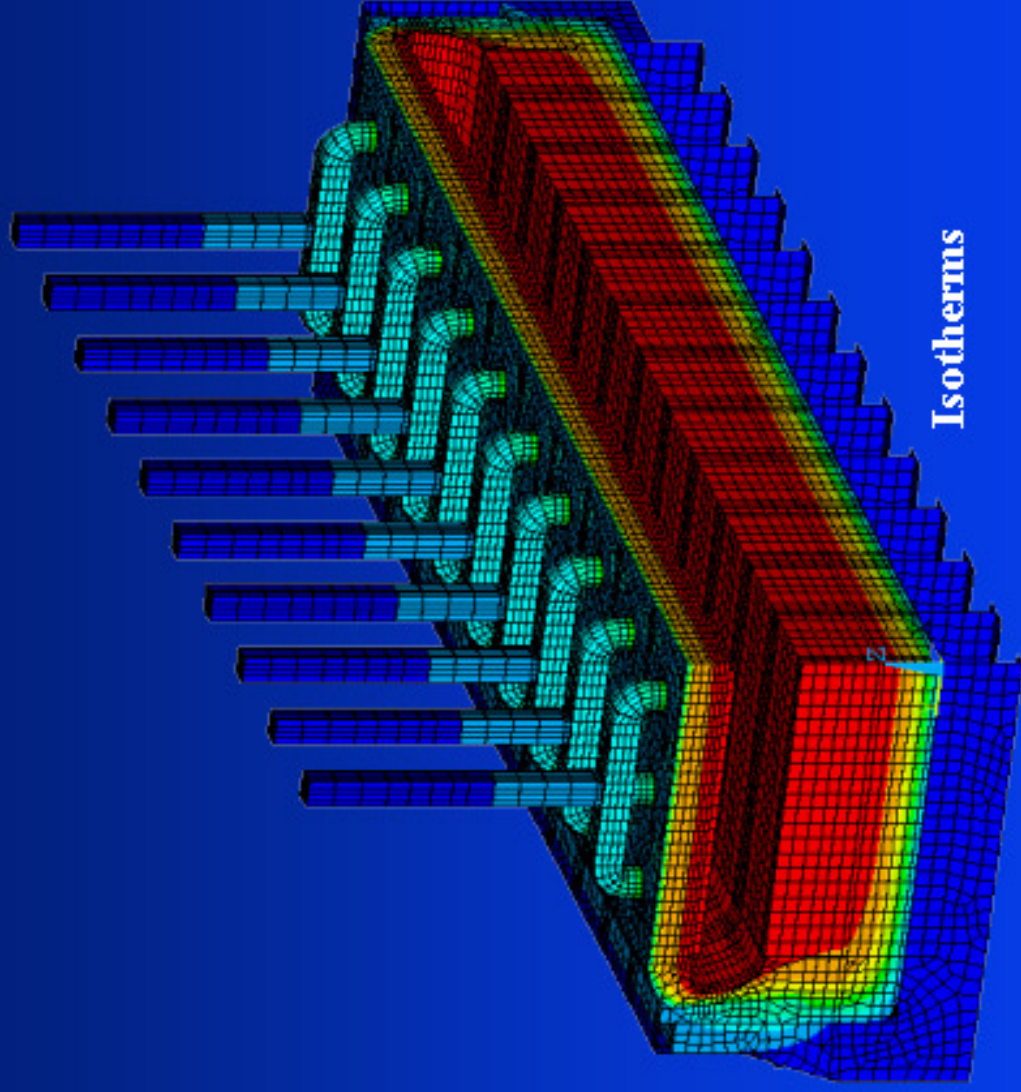
Introduction



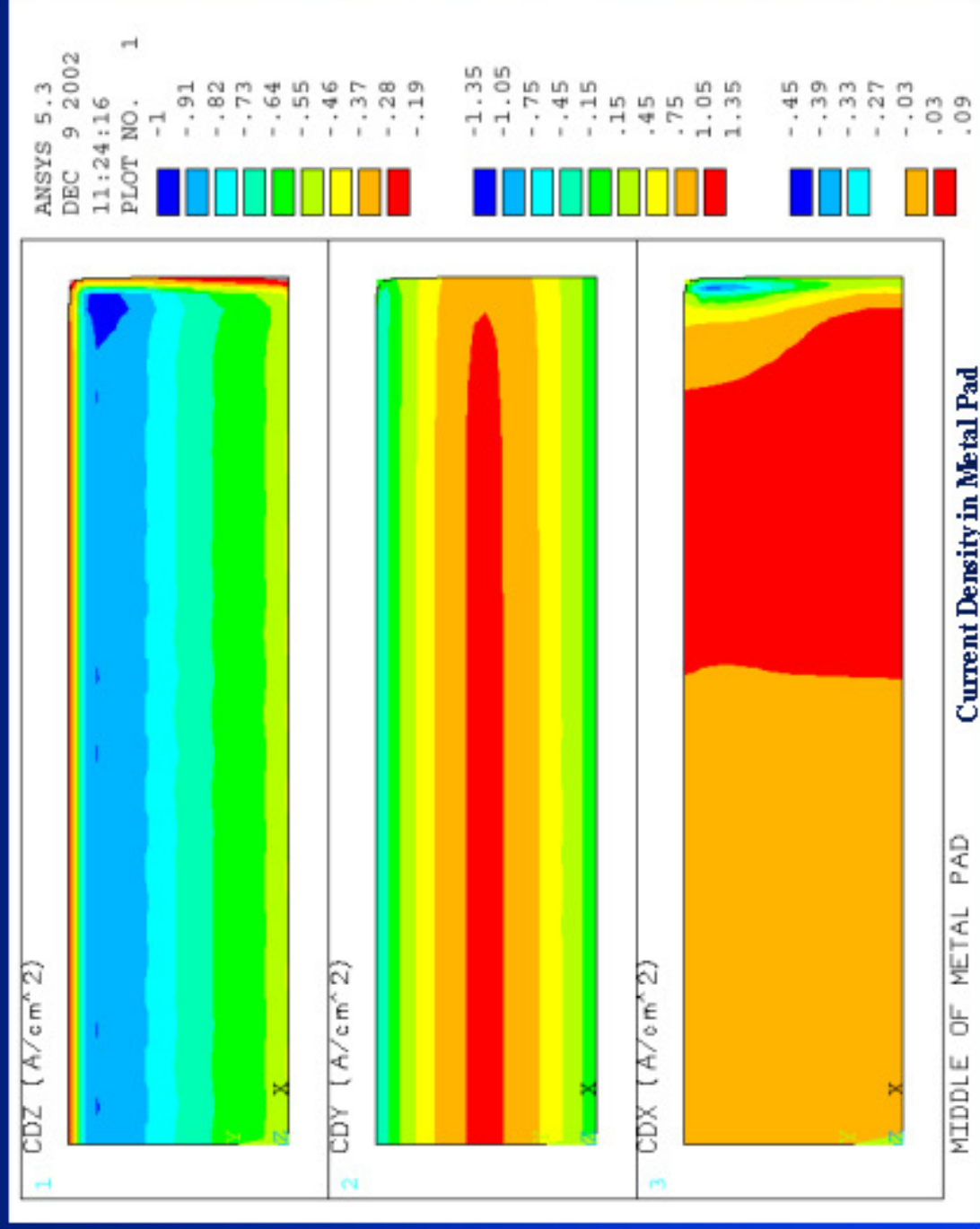
Full Cell Quarter T/E Model
of the 500 kA cell



Introduction



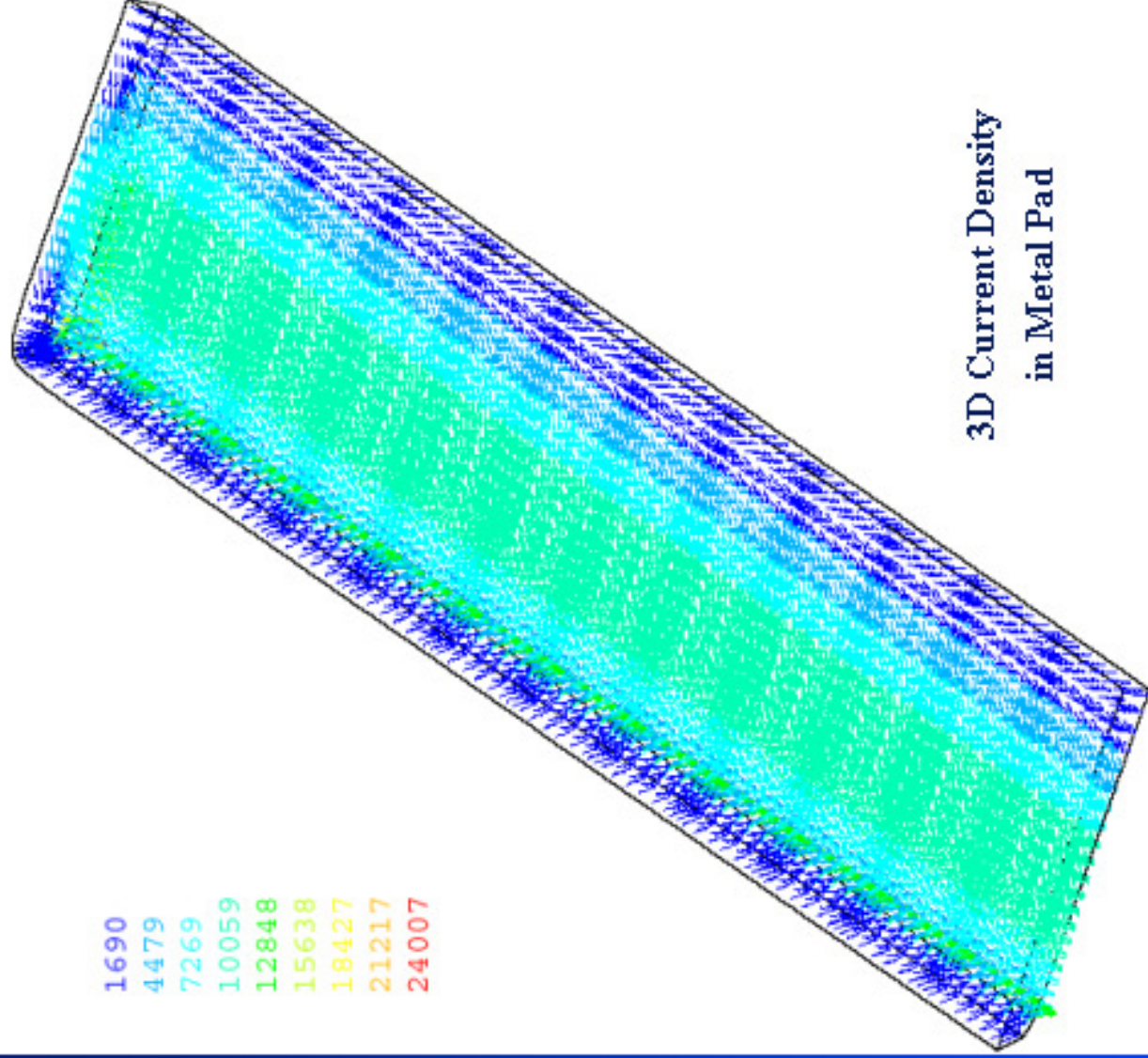
Introduction



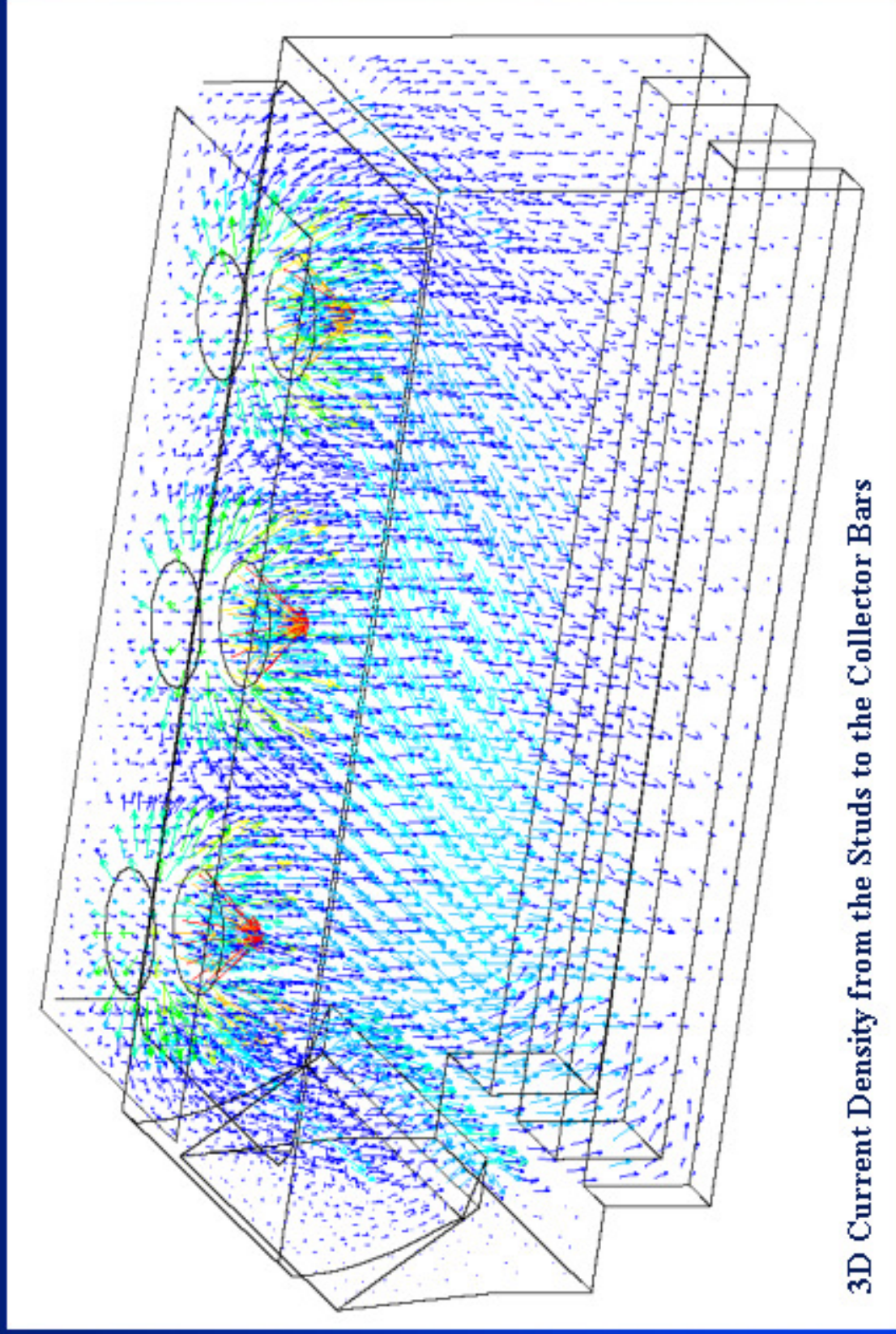
Introduction



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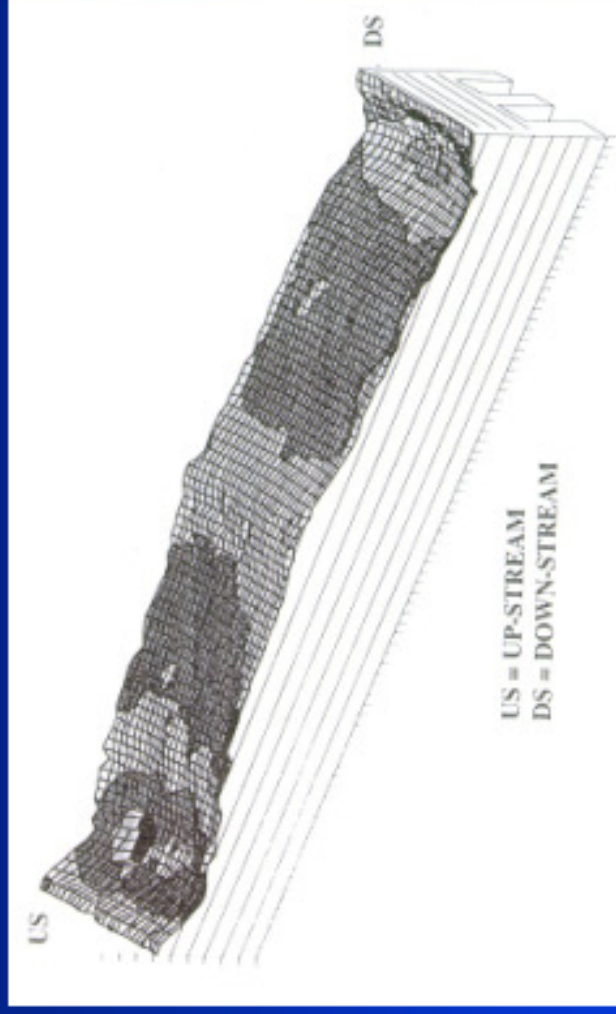


Introduction



3D Current Density from the Studs to the Collector Bars

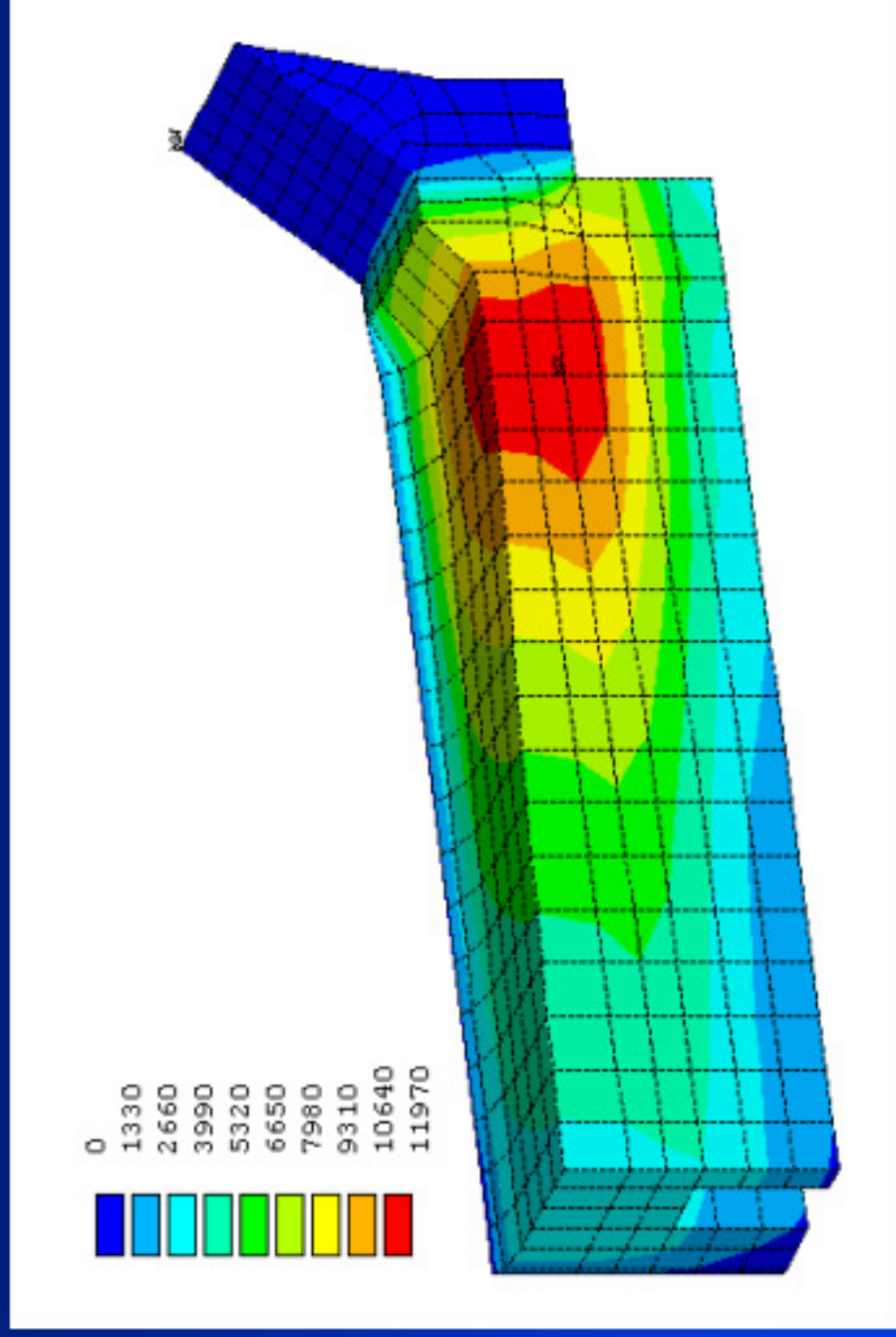
Introduction



- Extensive measurement campaigns clearly show that the erosion rate is proportional to the cathode block surface current density

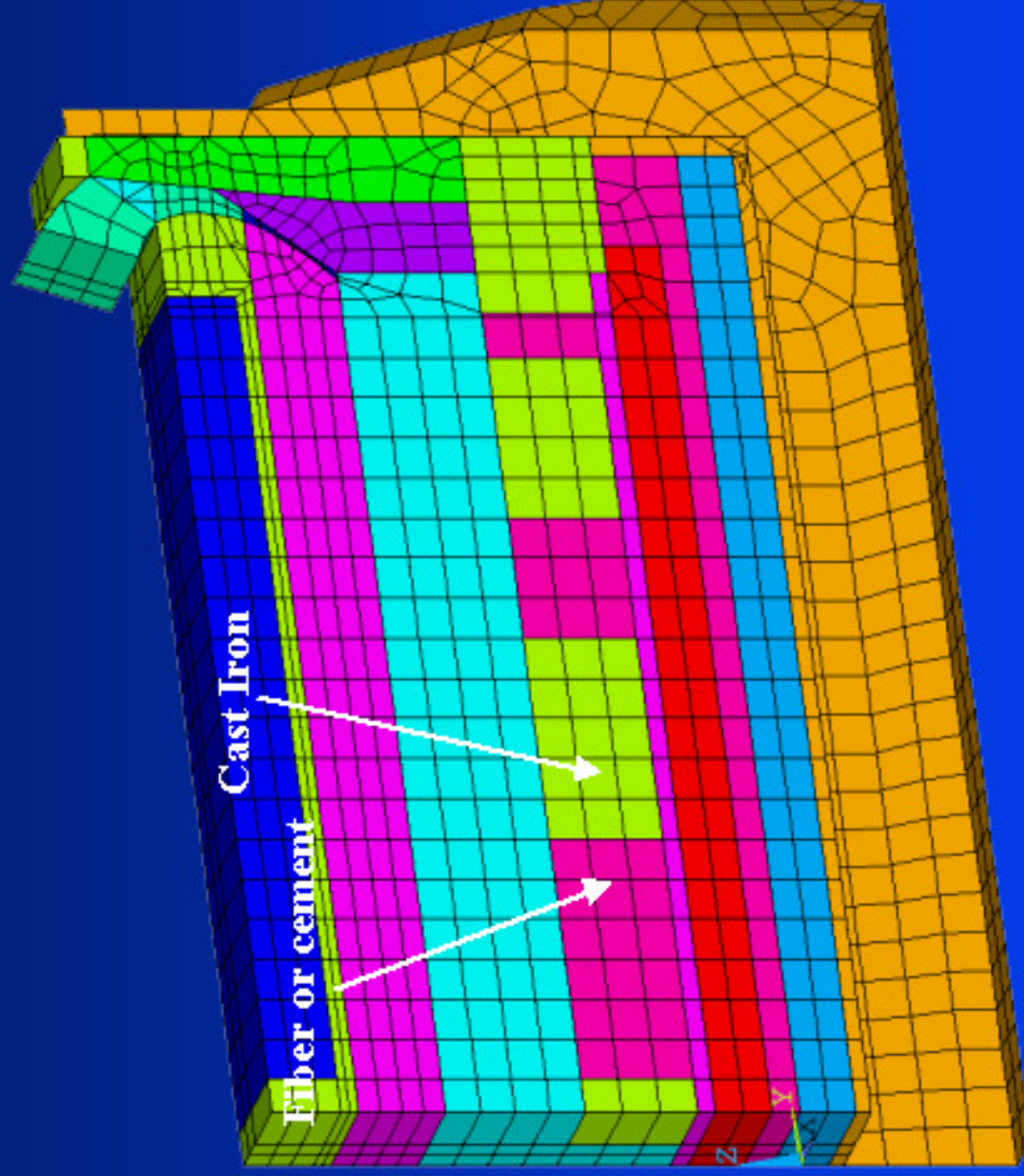


Introduction

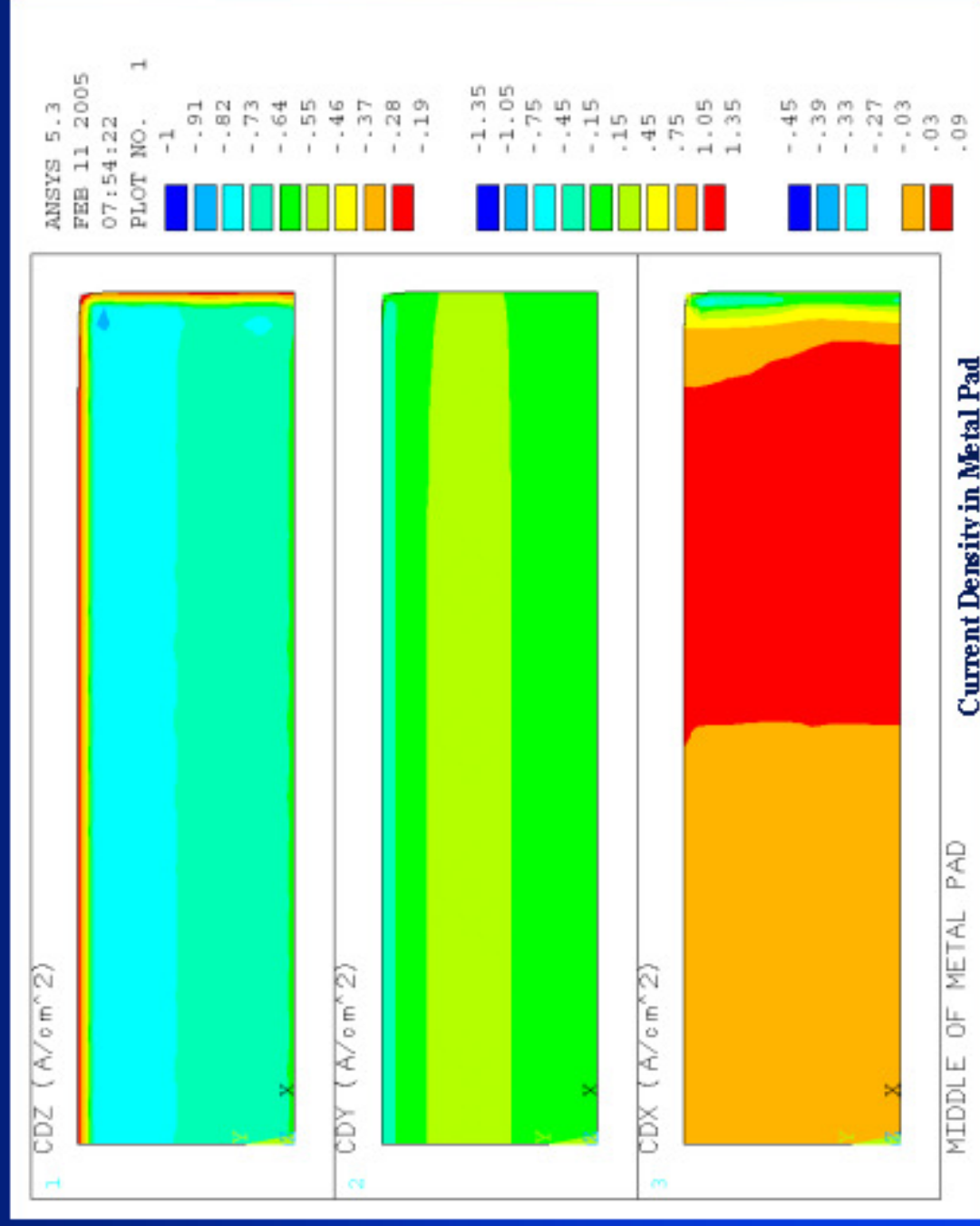


- Erosion profile after 2 years of operation

Selective Rodding Pattern



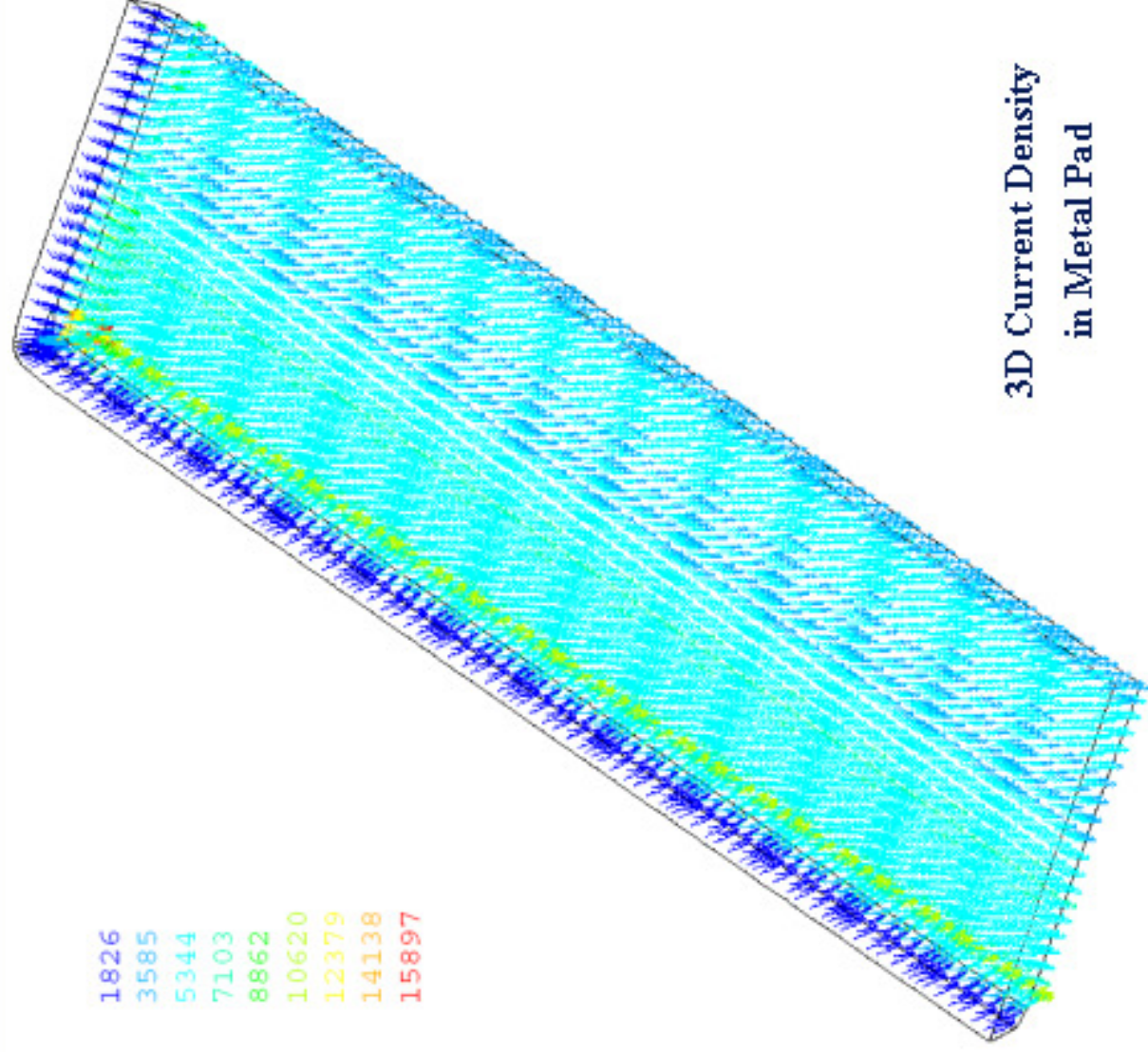
Selective Rodding Pattern



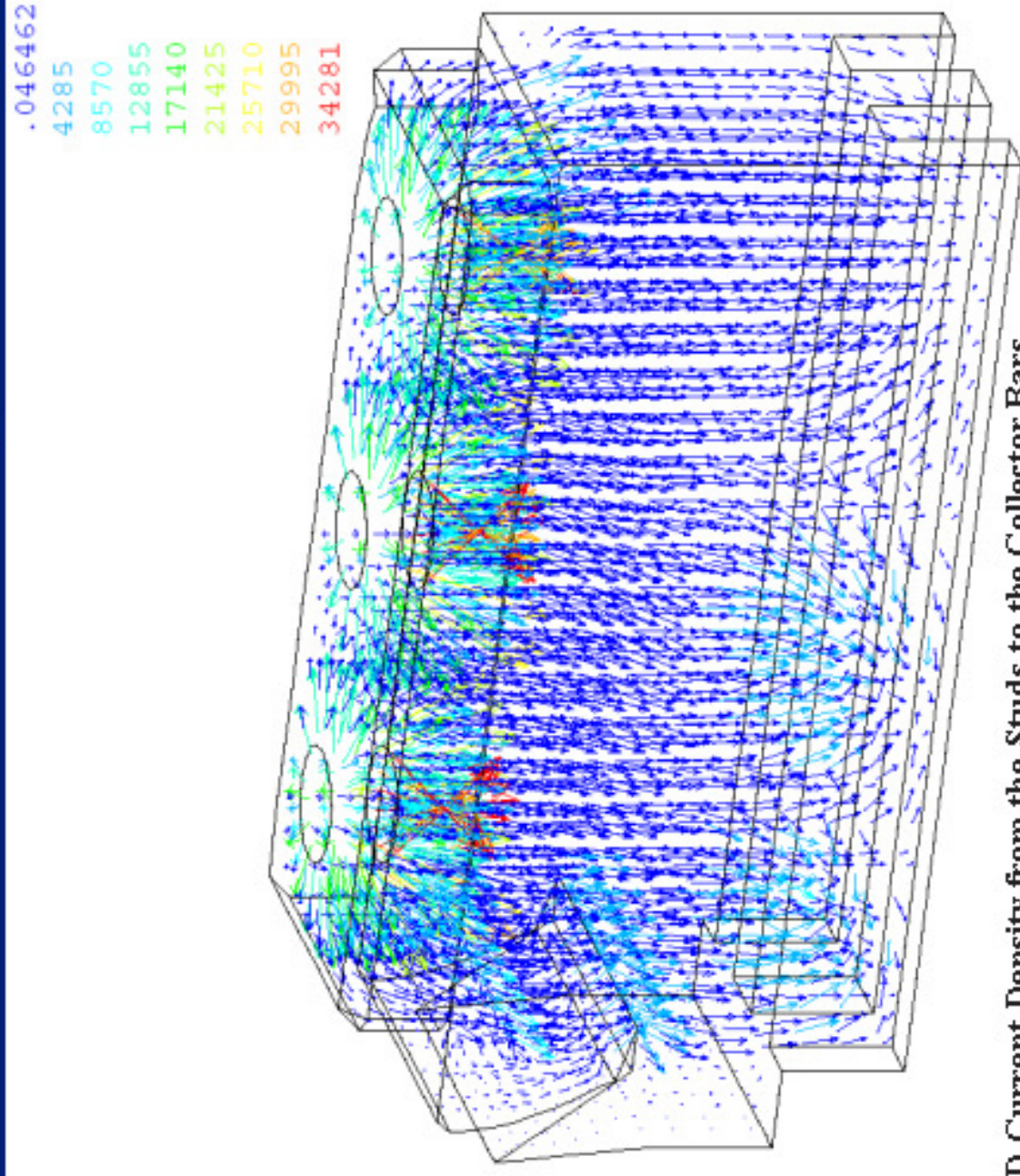
Selective Rodding Pattern



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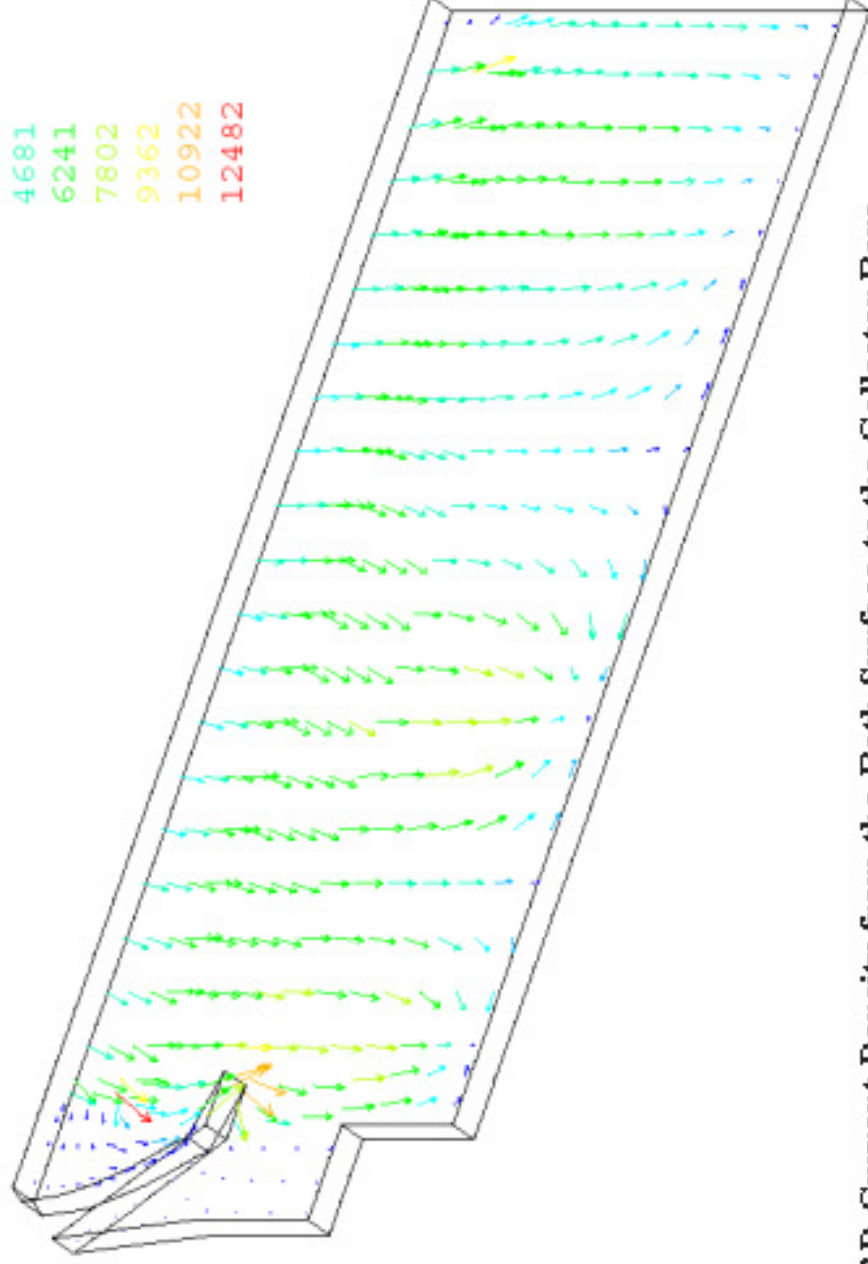
Selective Rodding Pattern



3D Current Density from the Studs to the Collector Bars

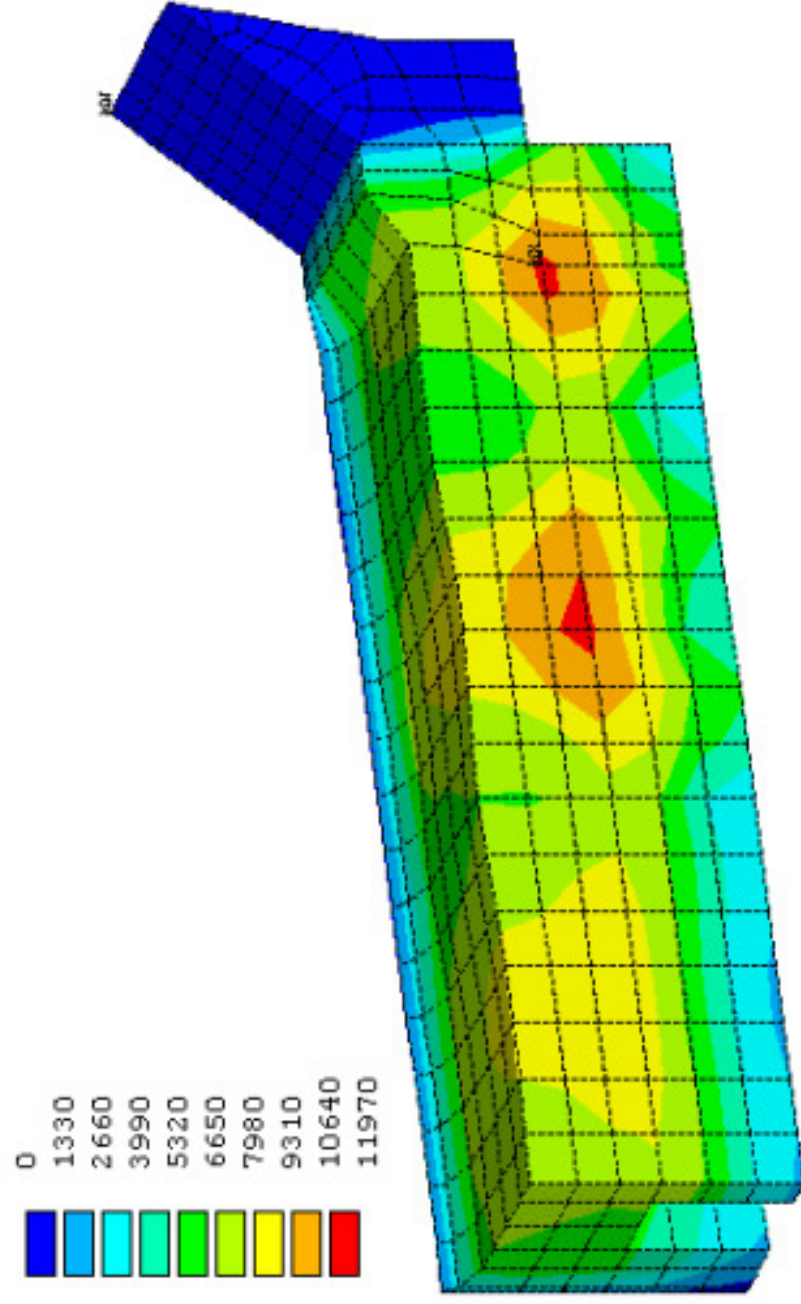
Selective Rodding Pattern

.053784
1560
3121
4681
6241
7802
9362
10922
12482



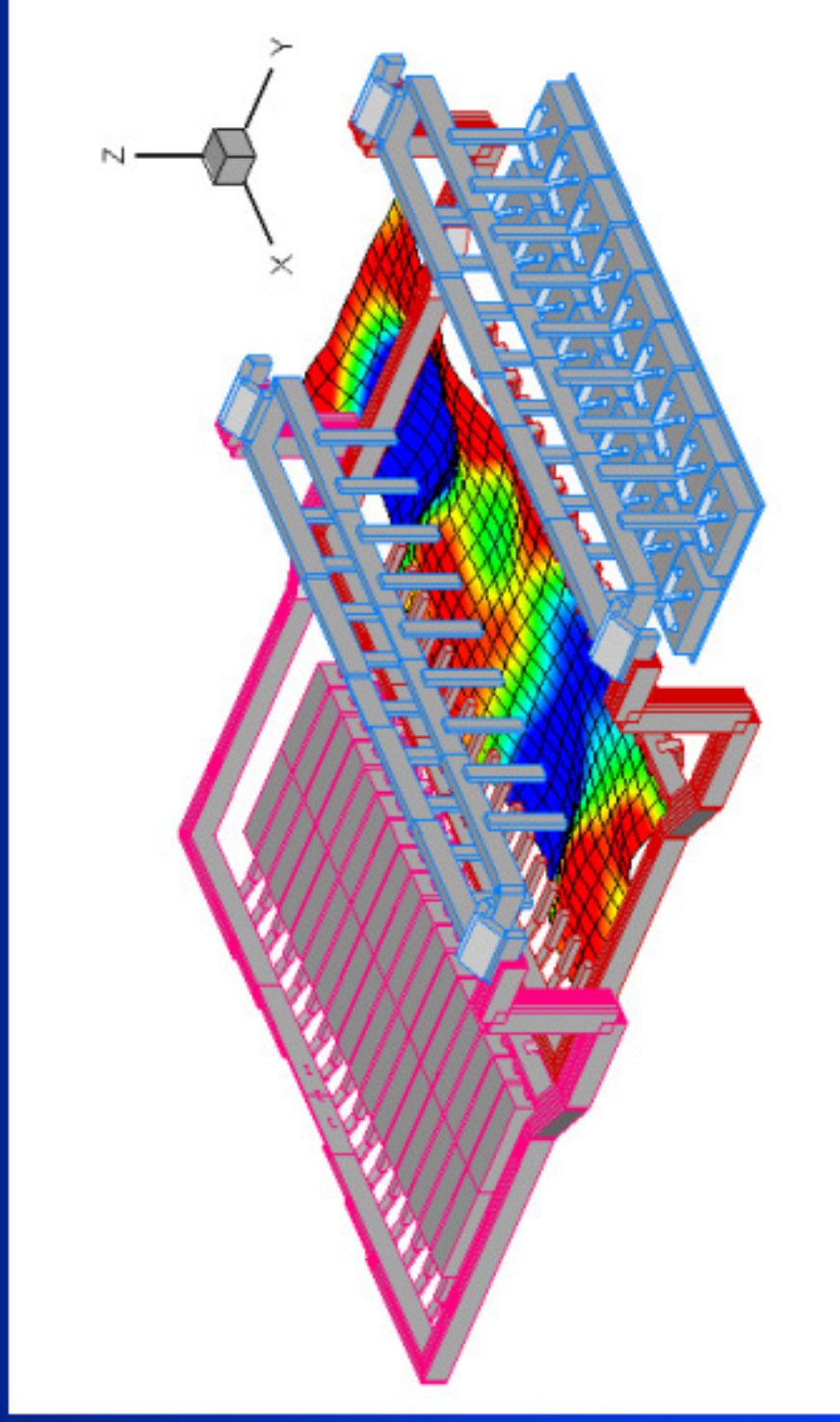
3D Current Density from the Bath Surface to the Collector Bars

Selective Rodding Pattern



- Erosion profile after 2 years of operation

MHD Computational Model: Electric Current Distribution



MHD Computational Model: Electric Current Distribution

Electric Current Distribution

$$\mathbf{j} = -\sigma \nabla \varphi; \quad \nabla^2 \varphi = 0 \text{ in busbars, electrodes}$$

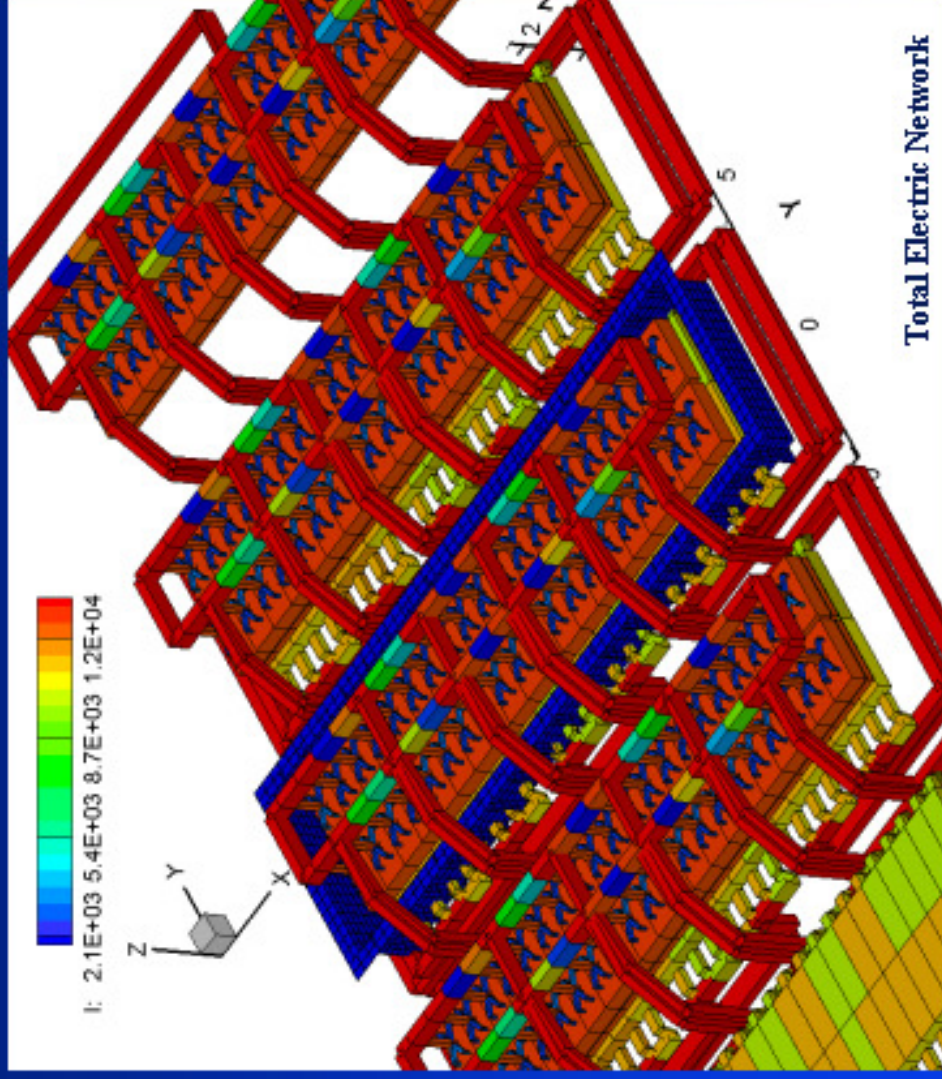
$$\mathbf{j} = -\sigma \nabla \varphi + \sigma \mathbf{v} \times \mathbf{B}, \quad \nabla^2 \varphi = \nabla \cdot (\mathbf{v} \times \mathbf{B}) \text{ in bath and metal}$$

Solution using the Kirchhoff Law

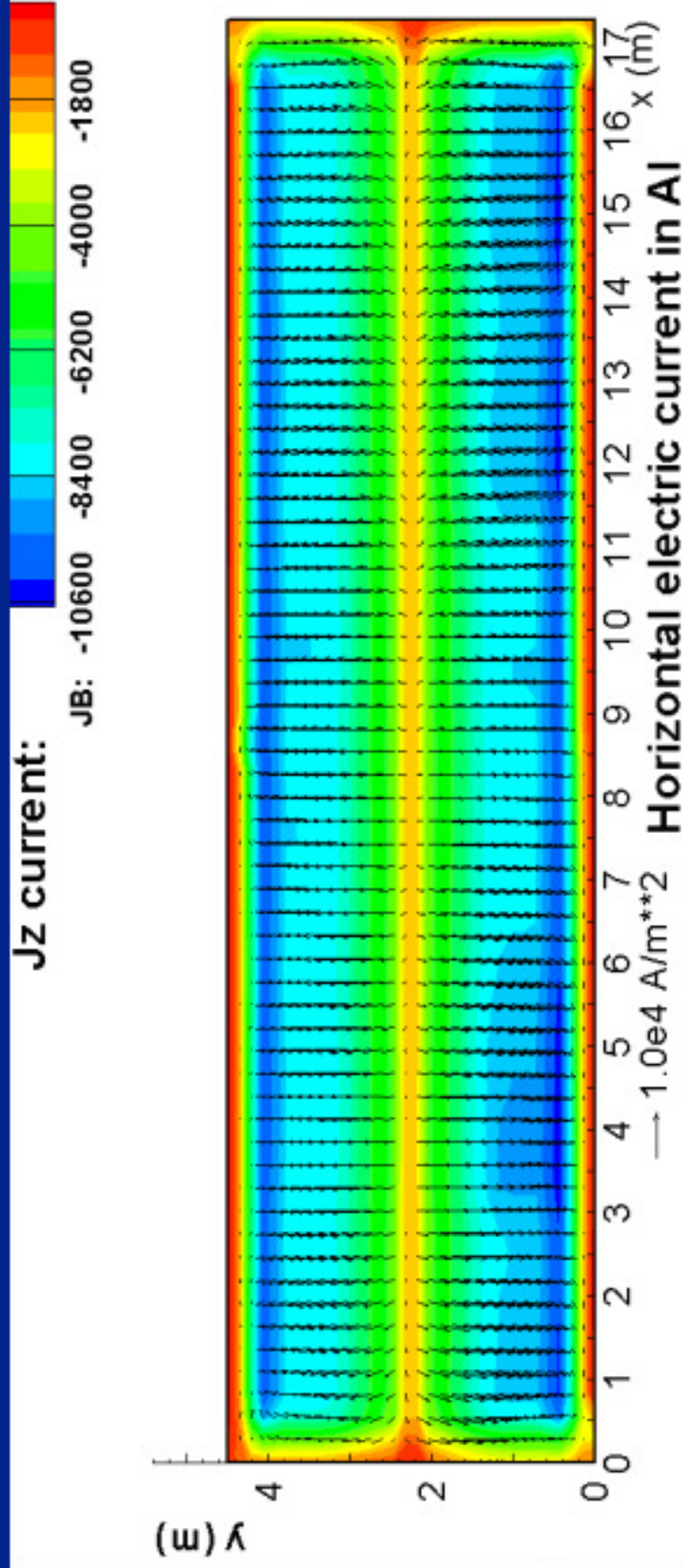
$$U_m \sum_{n=1}^N \frac{1}{R_n} - \sum_{n=1}^N \frac{U_n}{R_n} = I_m$$

$$\text{with } \rho_T = \rho_{20} \cdot (1 + \alpha T)$$

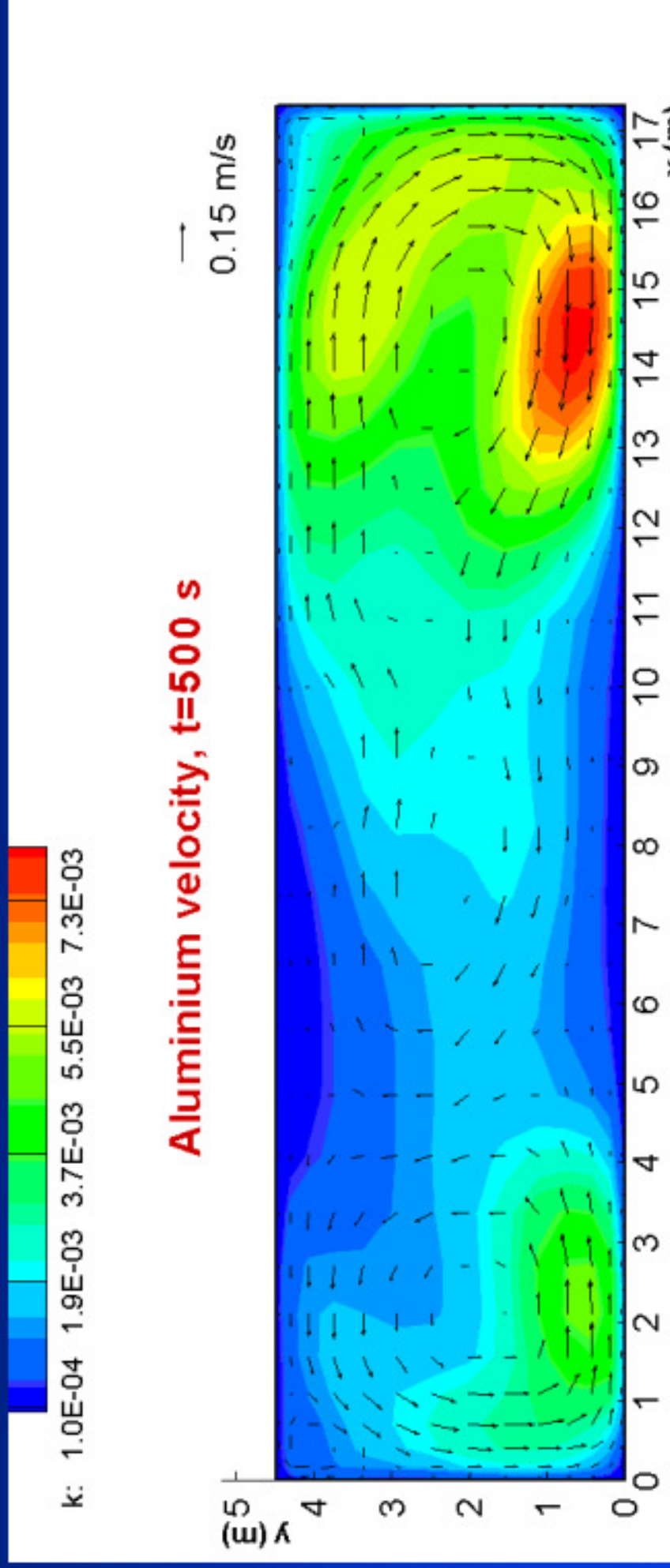
MHD Computational Model: Electric Current Distribution



MHD Modeling Results: Without Selective Rodding



MHD Modeling Results: Without Selective Rodding



MHD Modeling Results: Without Selective Rodding

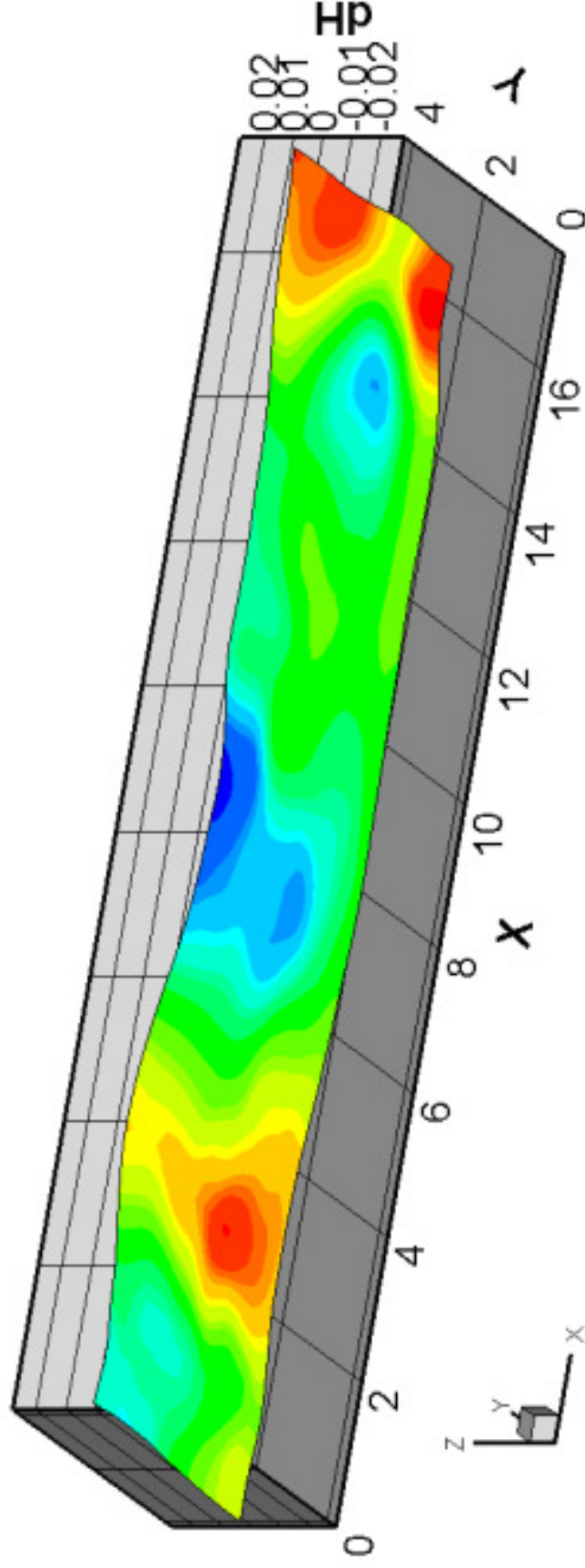
Liquid aluminium surface, $dH(m)$

$t = 500 \text{ s}$

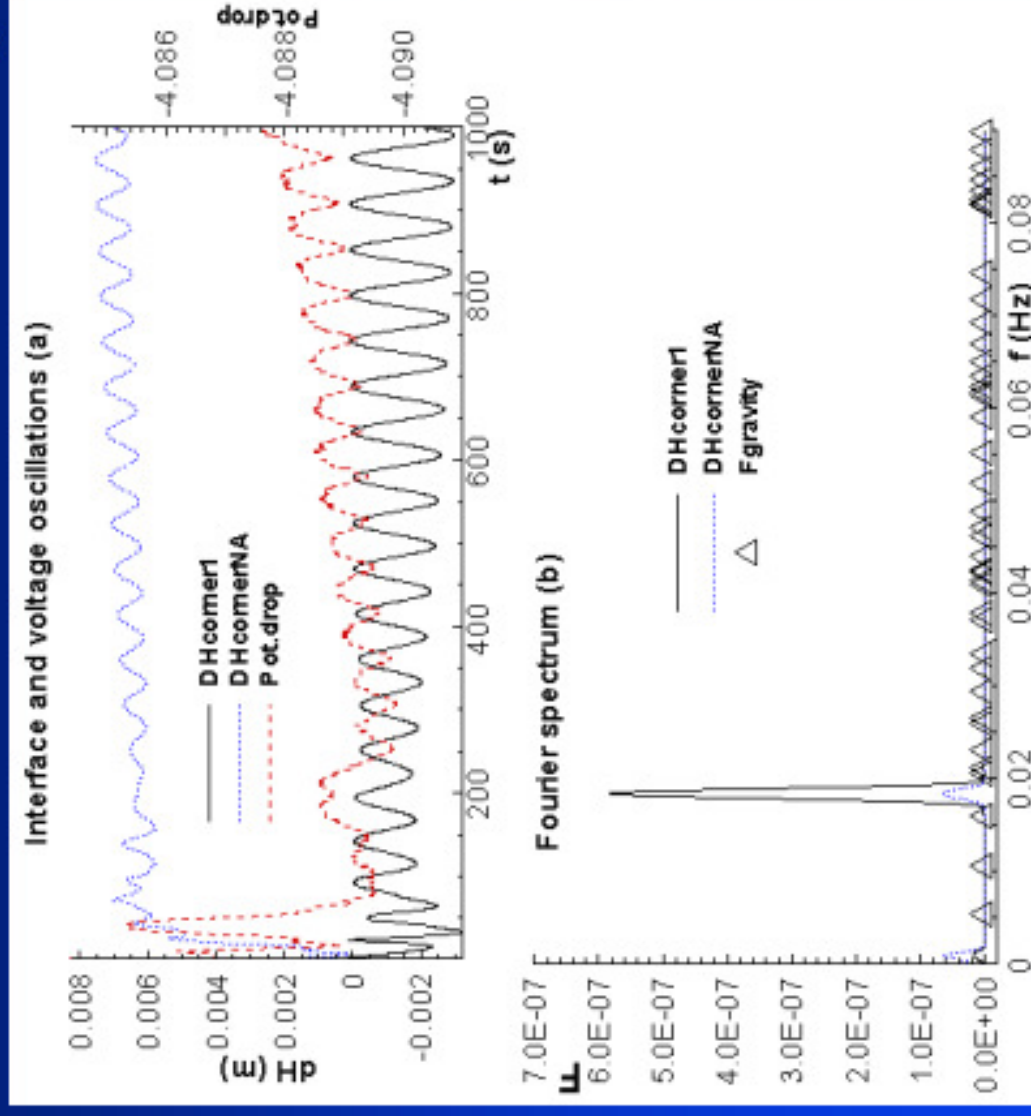
500 kA cell, return row 20 m

Uniform ledge 0.20 m

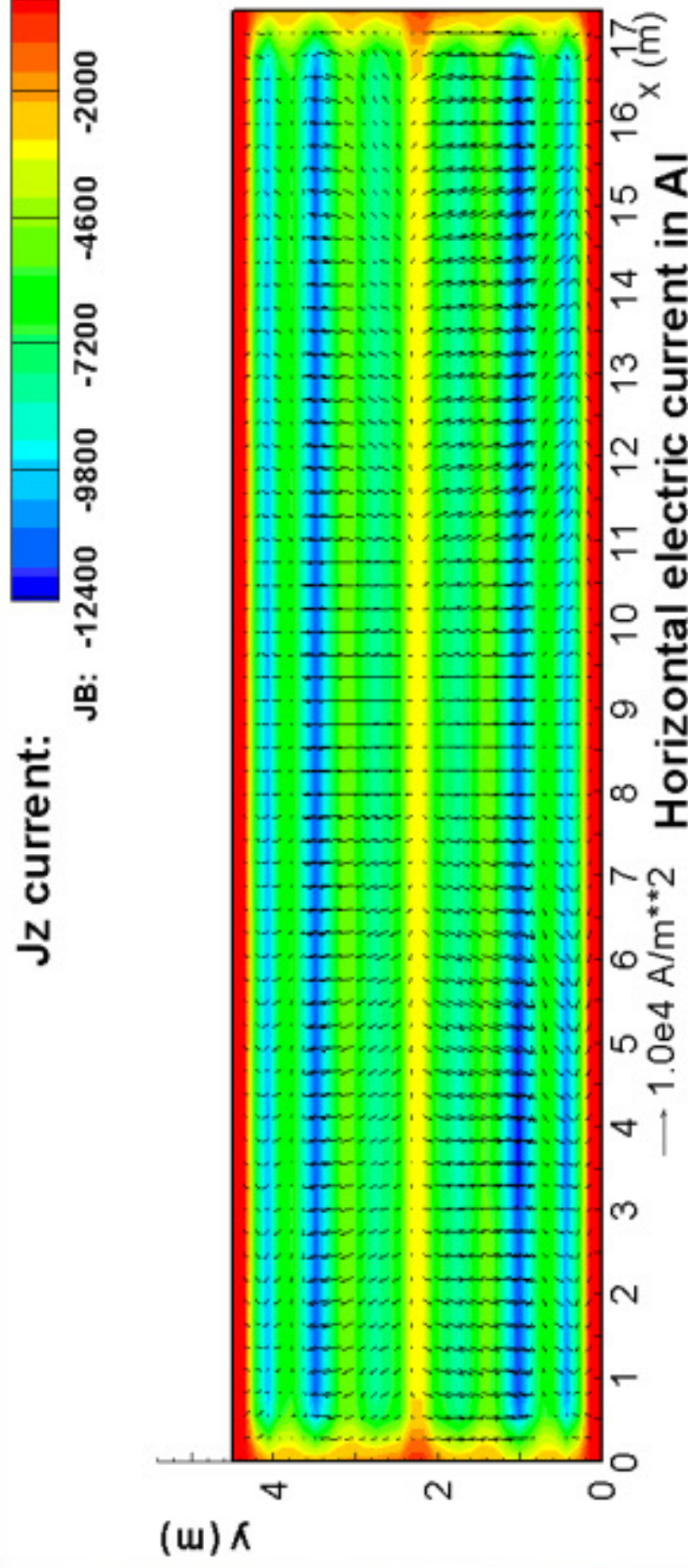
Cell close to end of line



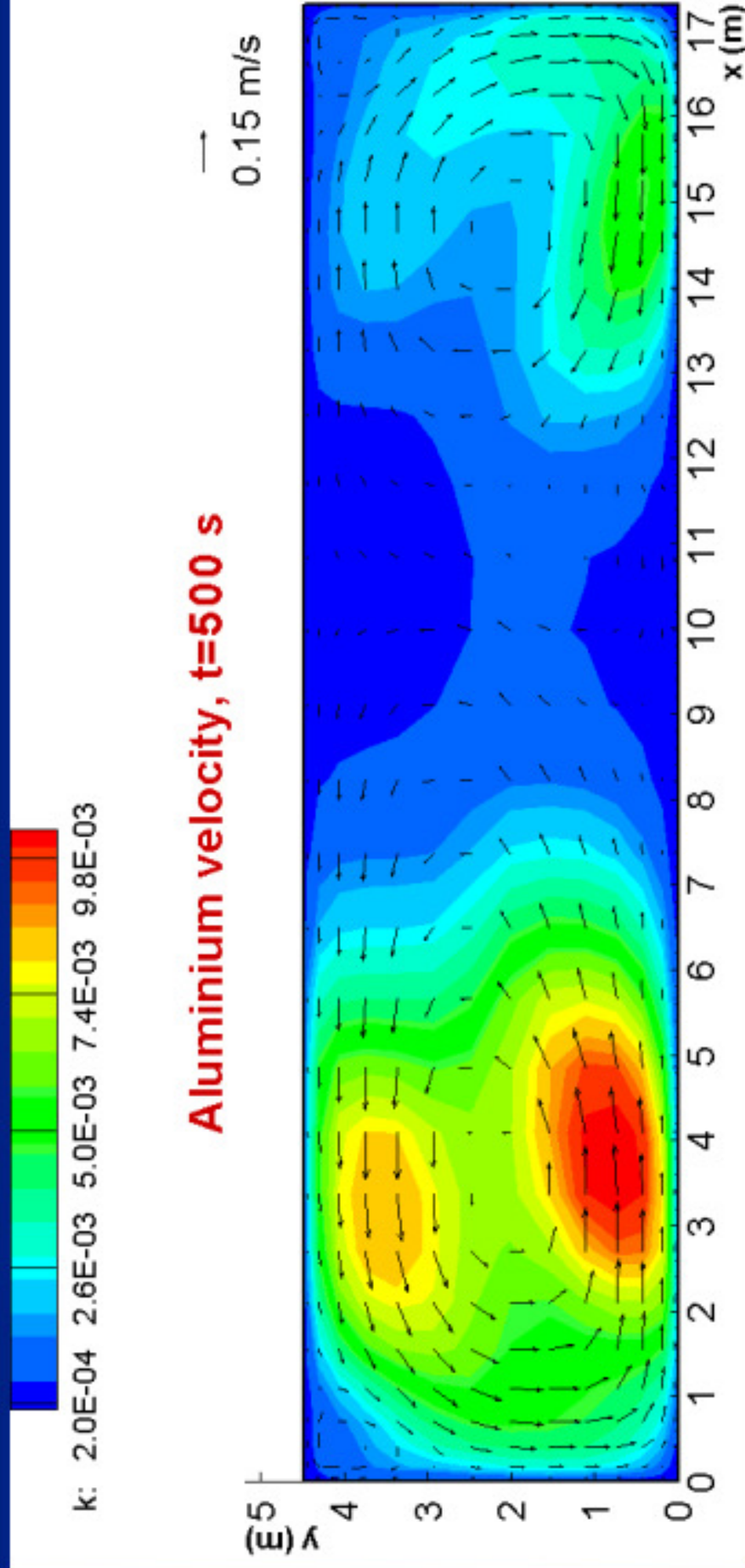
MHD Modeling Results: Without Selective Rodding



MHD Modeling Results: With Selective Rodding

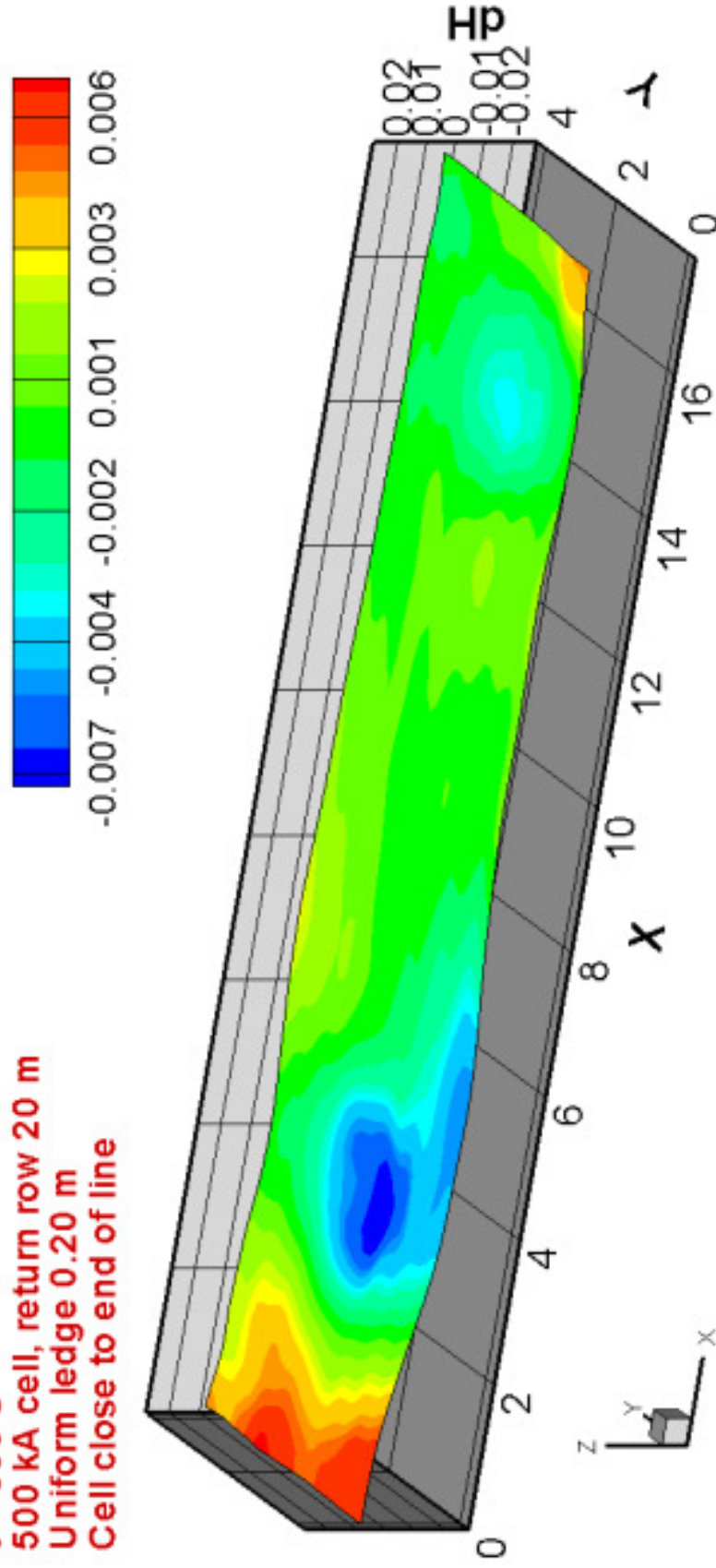


MHD Modeling Results: With Selective Rodding

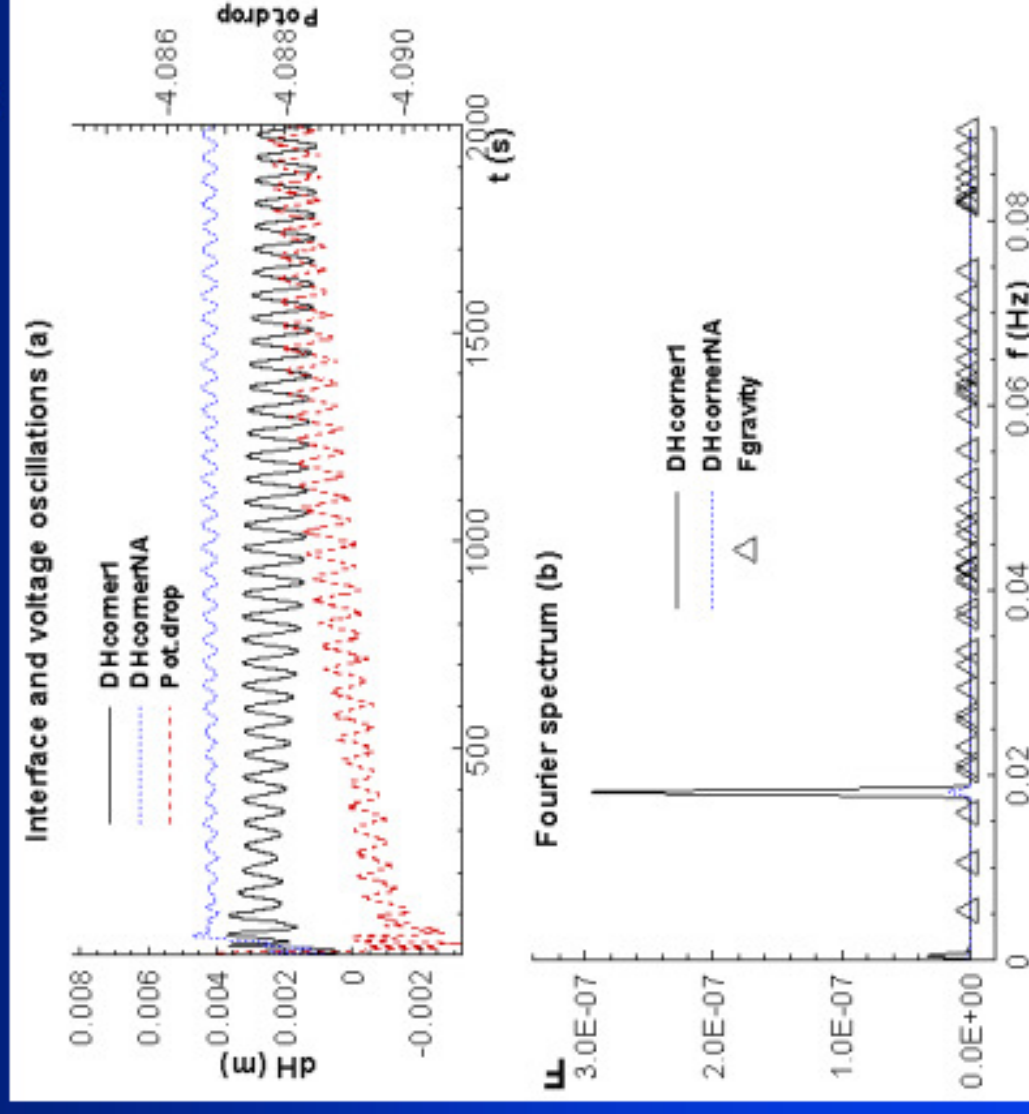


MHD Modeling Results: With Selective Rodding

Liquid aluminium surface, $dH(m)$
 $t = 500 \text{ s}$
 500 kA cell, return row 20 m
 Uniform ledge 0.20 m
 Cell close to end of line



MHD Modeling Results: With Selective Rodding



Conclusions

- In order to get a uniform current density at the metal/cathode block interface, the rodding of each collector bar is split in three sections of decreasing size while going from the center of the cell side wall. The length of the middle section is half of the section close to the cell center while the section close to the cell wall is about one third of the middle section.
- As demonstrated previously, having a uniform current density at the metal/cathode block interface also almost completely eliminates the horizontal currents in the metal pad.
- The MHD stability modelling for the experimental high amperage 500 kA cells indicates that the selective collector bar rodding can be useful for reducing the cell noise and increasing the stability. The effect may be particularly useful for the end of line cells where the stability is often compromised.

