SAND2007-4164C

MODELING OF A COMPACT PULSER FOR ISENTROPIC COMPRESSION EXPERIMENTS*

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* Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the U.S. Department of Energy under Contract No. DE-AC04- 94AL85000.

[a]Ktech Corporation

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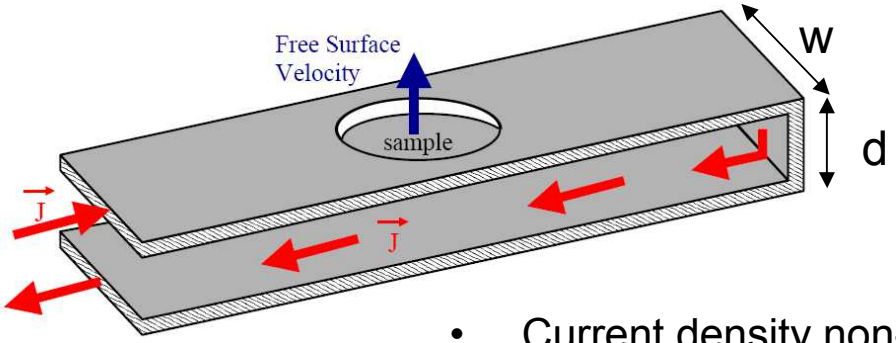
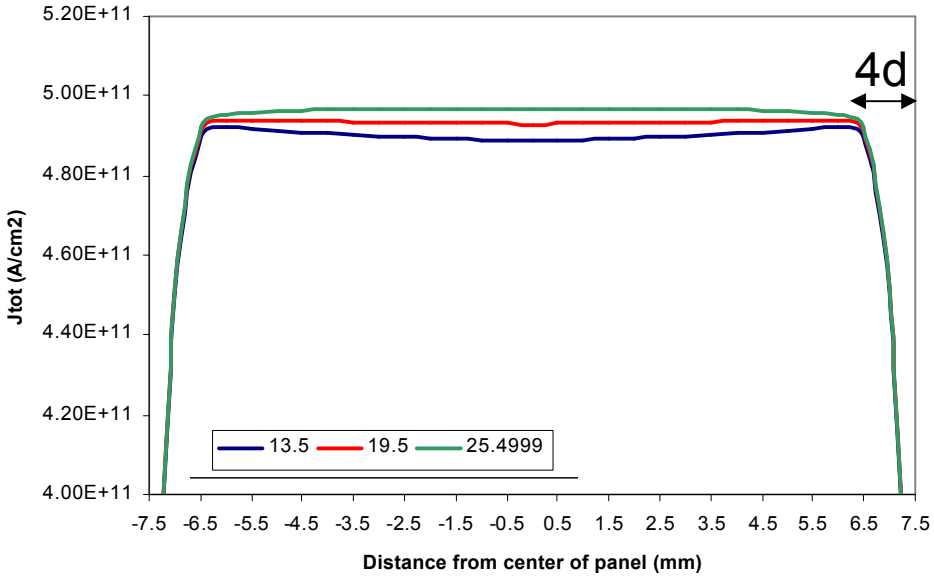
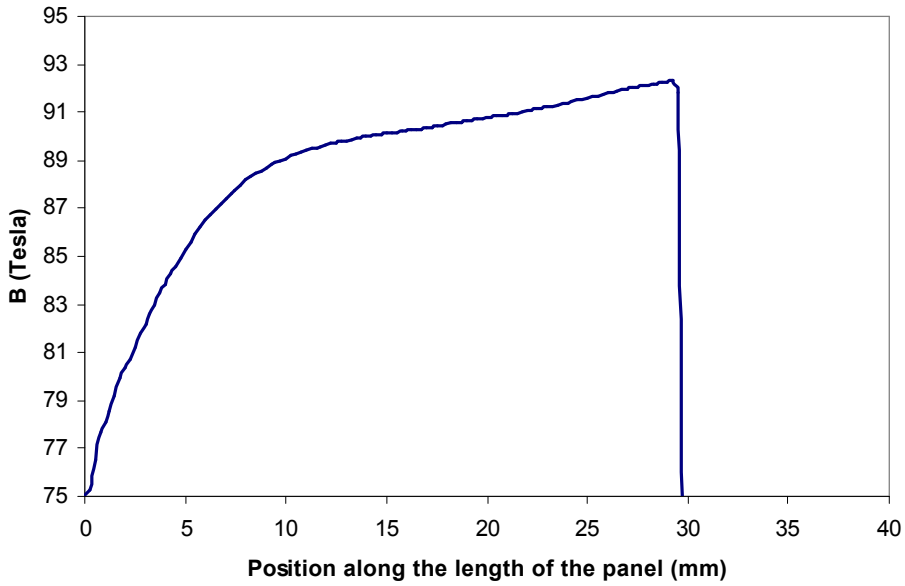
Pressure uniformity issues in magnetically driven strip line configuration experiments



$$P_{mag} = K_I \cdot \frac{\mu_0}{2} \left(\frac{I}{w}\right)^2$$

- Current density non-uniformity at the entrance of the strip line
- Current density rises along the length of strip line



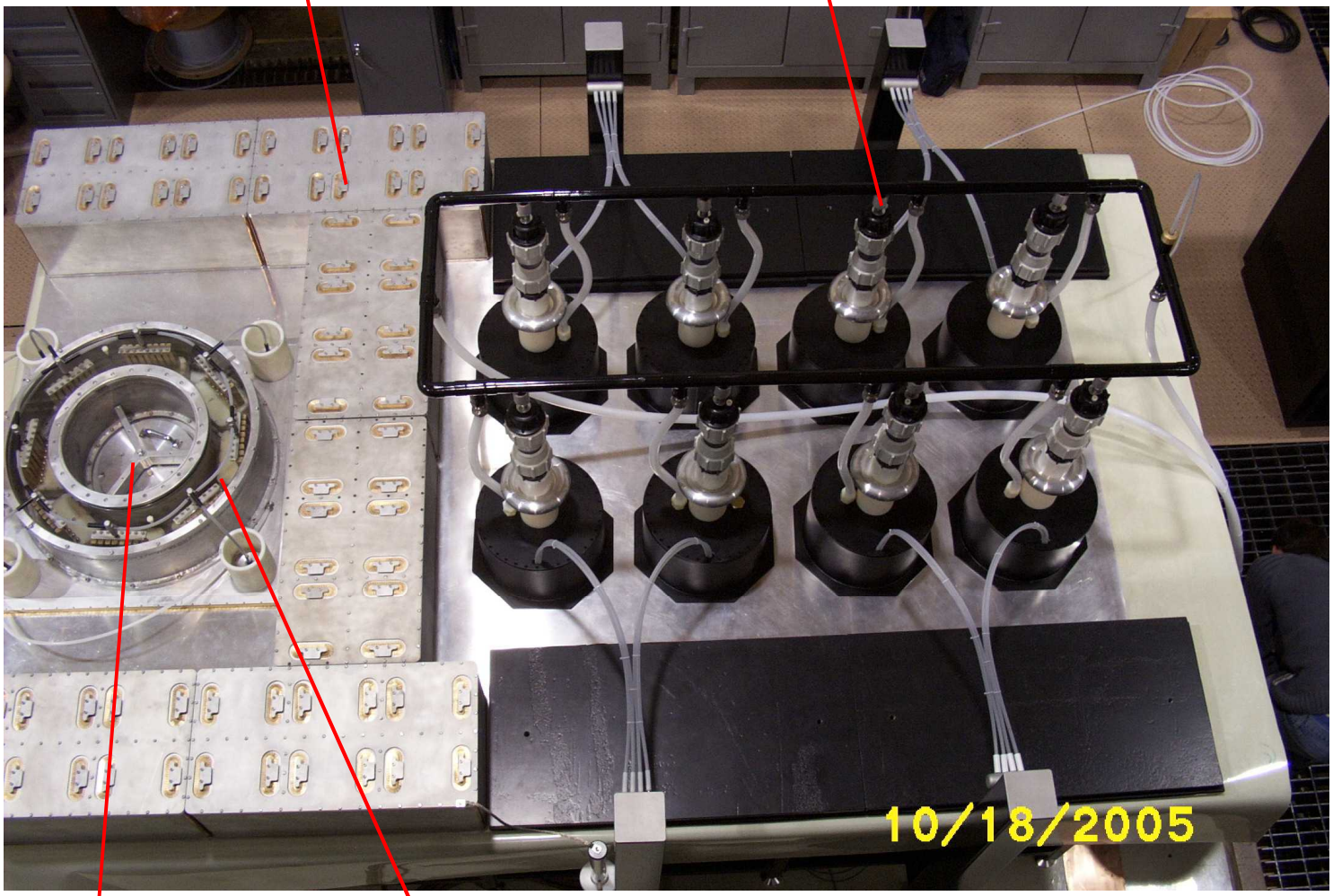


VELOCE

B4 7: R.B. Spielman, at al (Monday)
K1.00045: G. Avrillaud, et al (Tuesday)
Q4 6: T. Jaglinski, et al (this session)
Q4 7: T. Ao, et al (this session)

48 peaking capacitors

8 main capacitors



Load chamber

Dynamic Switch

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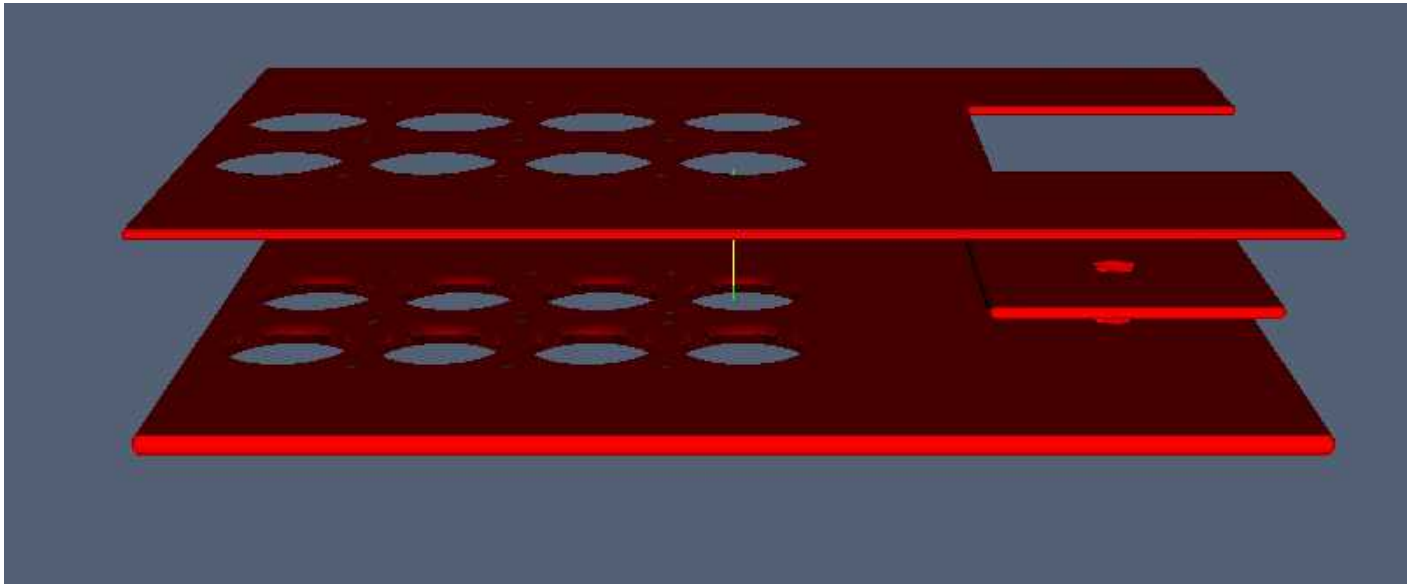
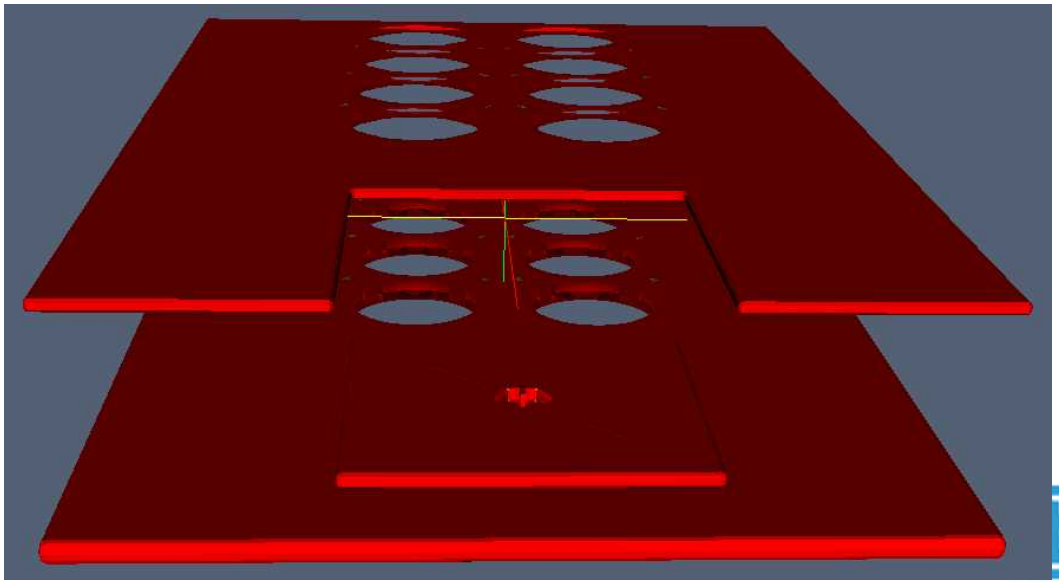
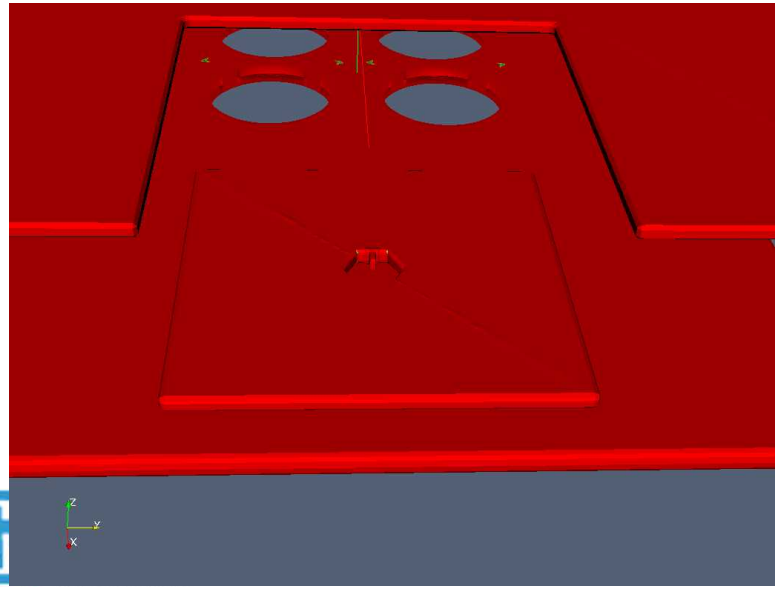
Modeling of Veloce pulser

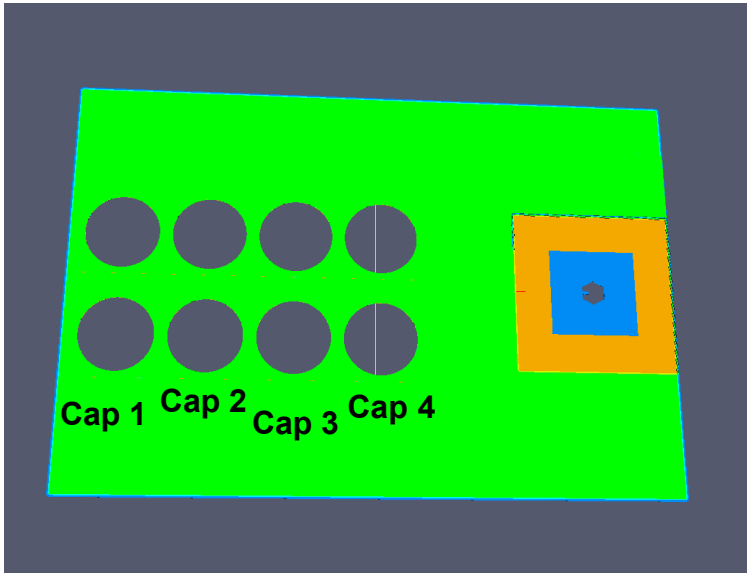


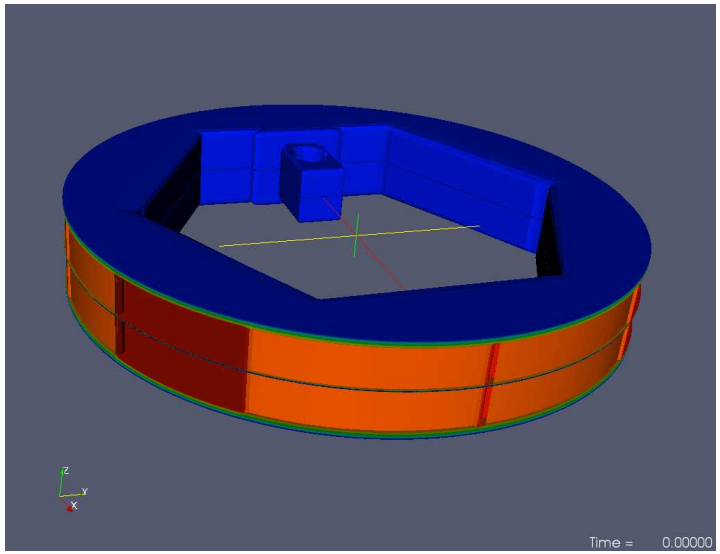


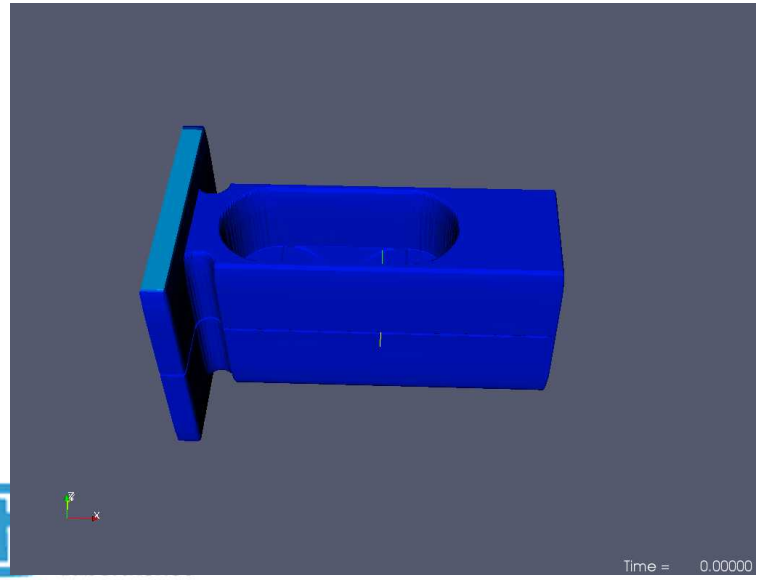


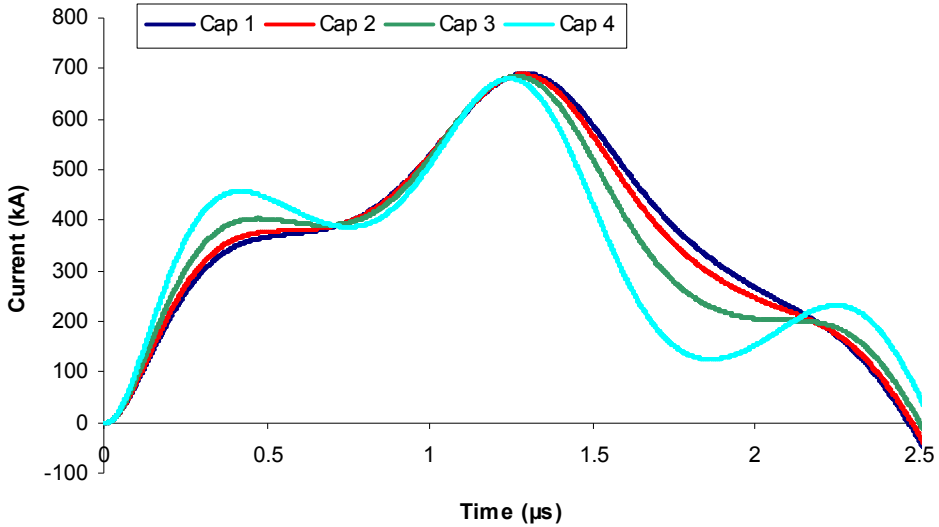
VELOCE MHD Simulations

Goal: optimize current uniformity of the sample panel

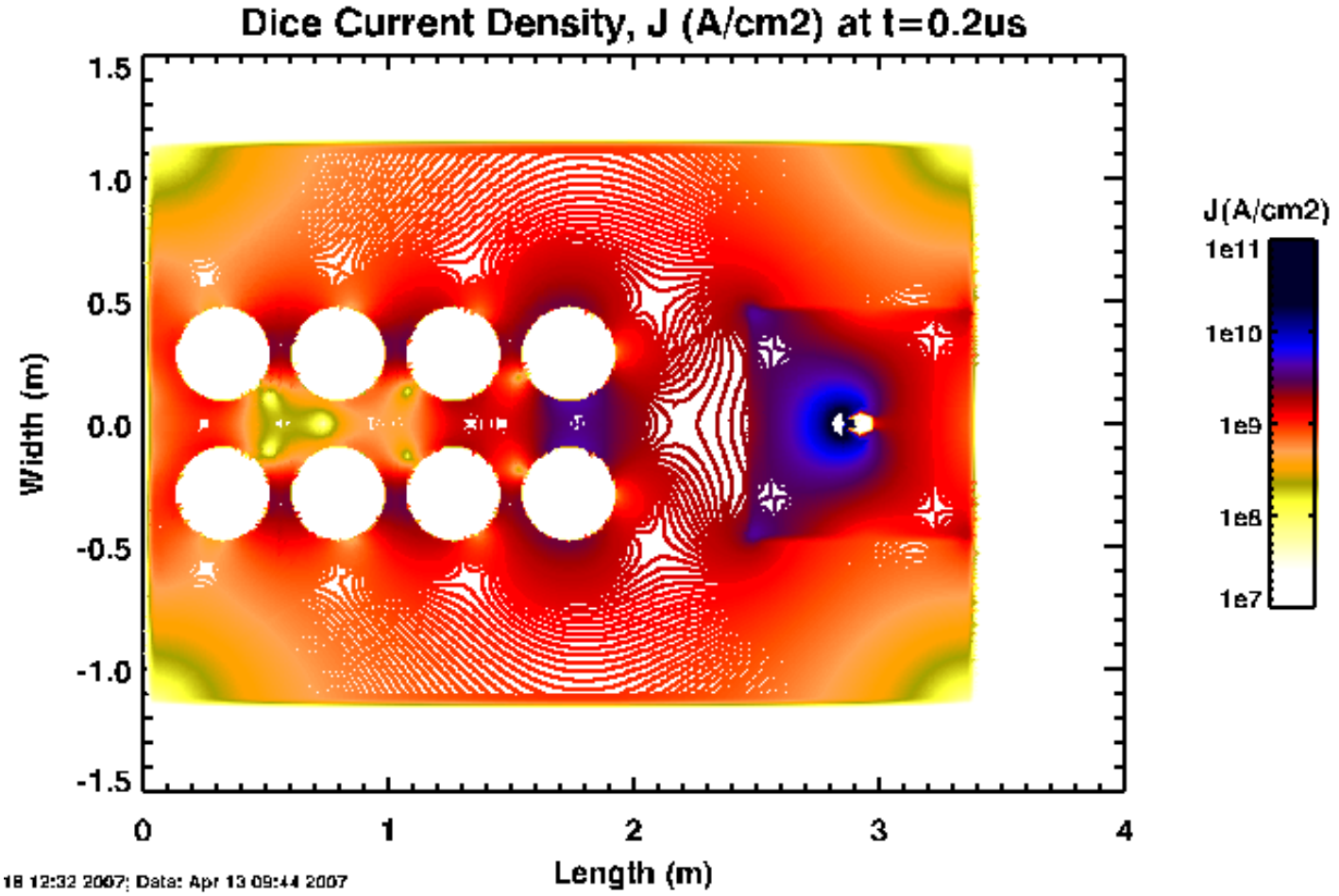








VELOCE Simulations: full machine



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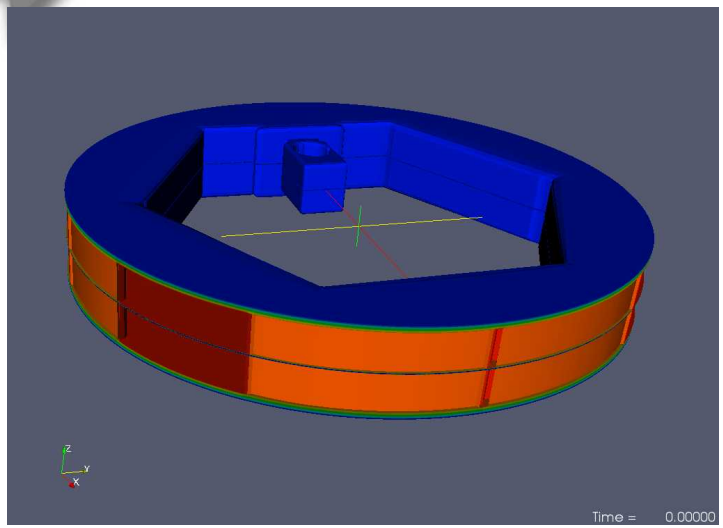
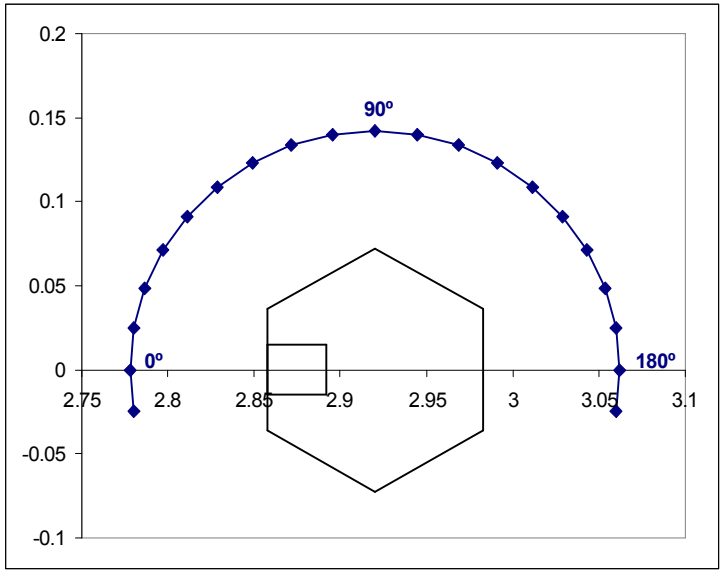
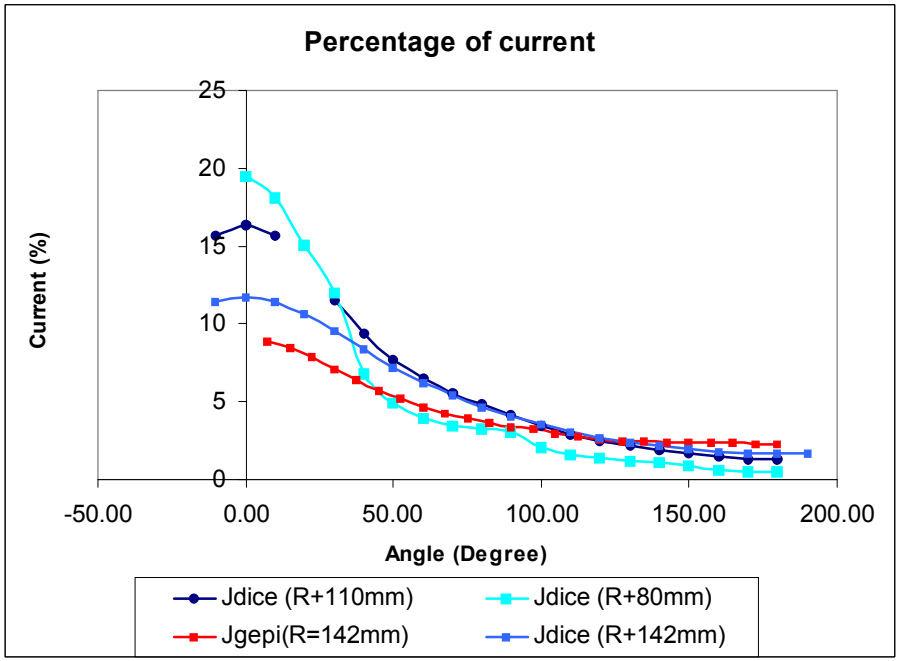
VELOCE Simulations: Load Area



Circular boundary: input current distribution from whole Veloce simulation
Current distribution more favorable than for the French machine GEPI





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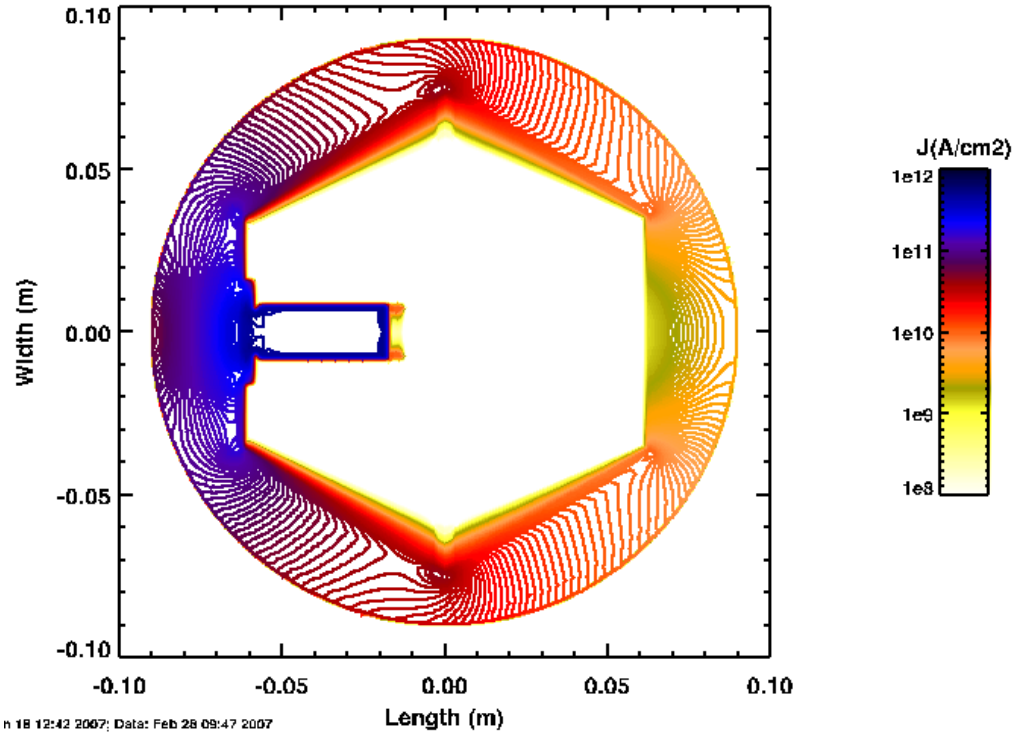
VELOCE Simulations: Load Area

Most of the current distributed on panel side



- Resolution limited because of size of simulation → Simulation of panel
- Input current distribution for panel simulation provided by whole load area simulation

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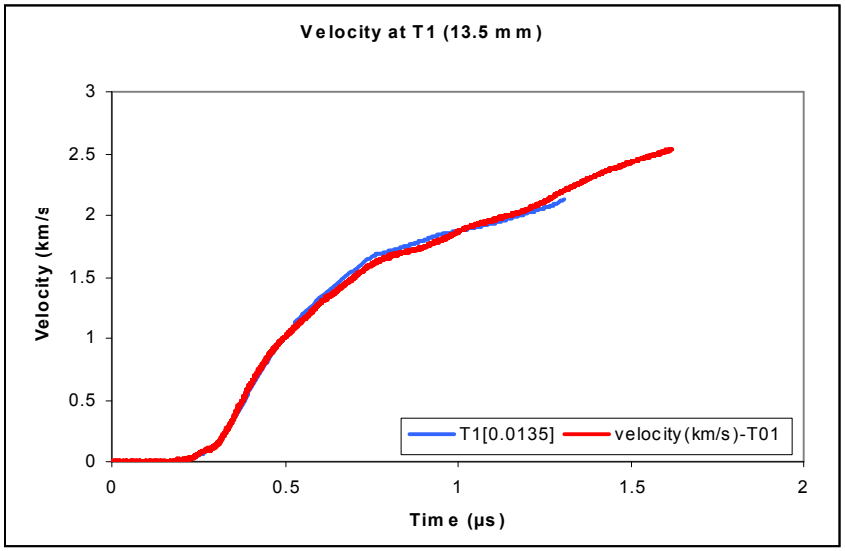
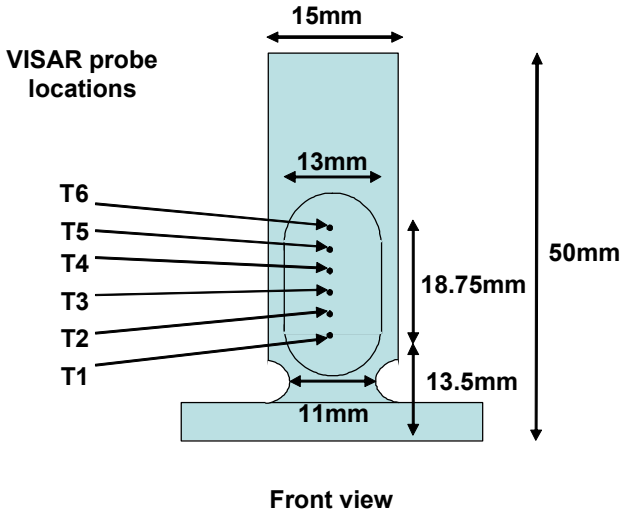
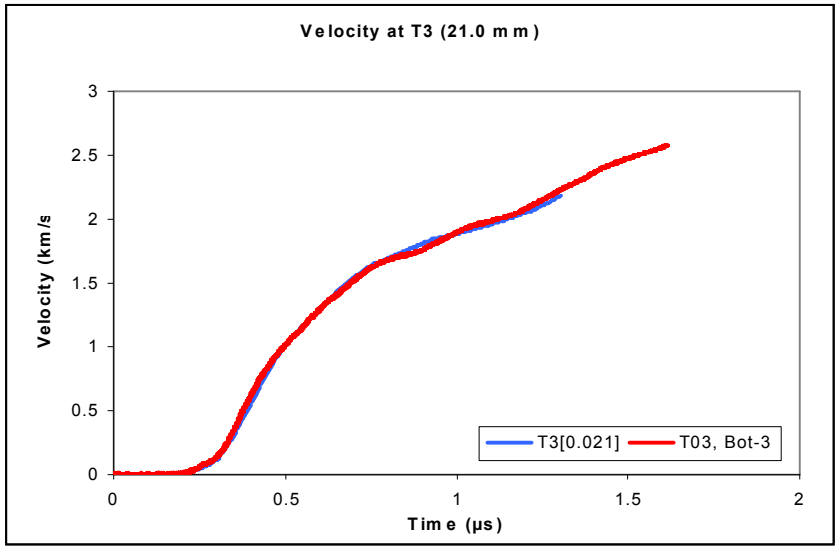
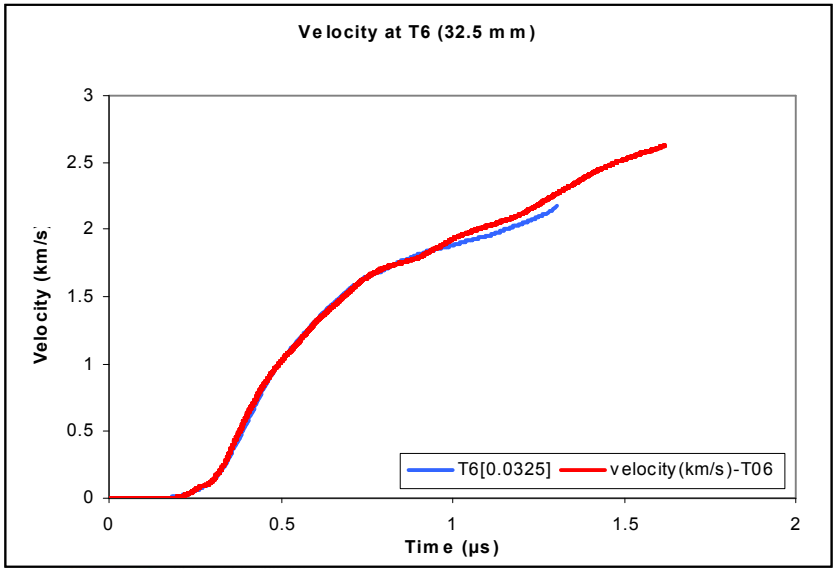
DICE Simulations: Load Area

Comparison of measured and calculated free surface velocity at different probe positions
(– model – experiment)



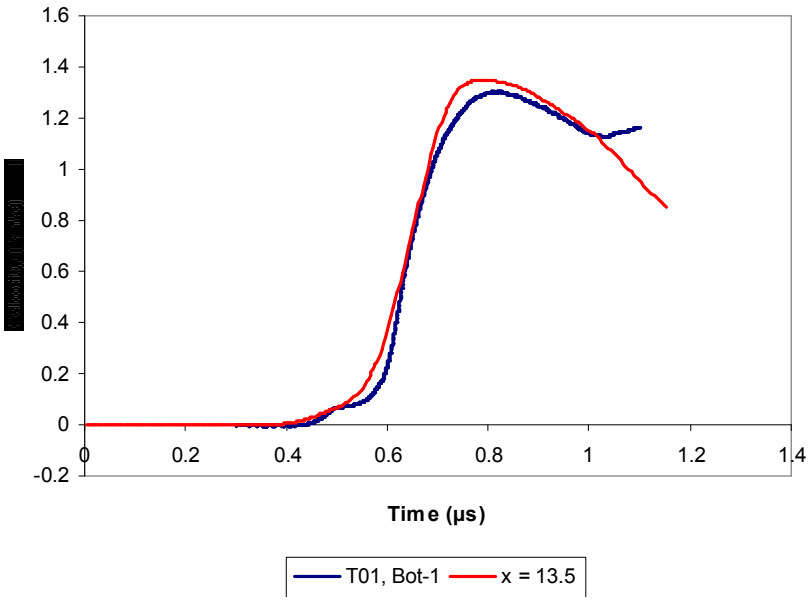


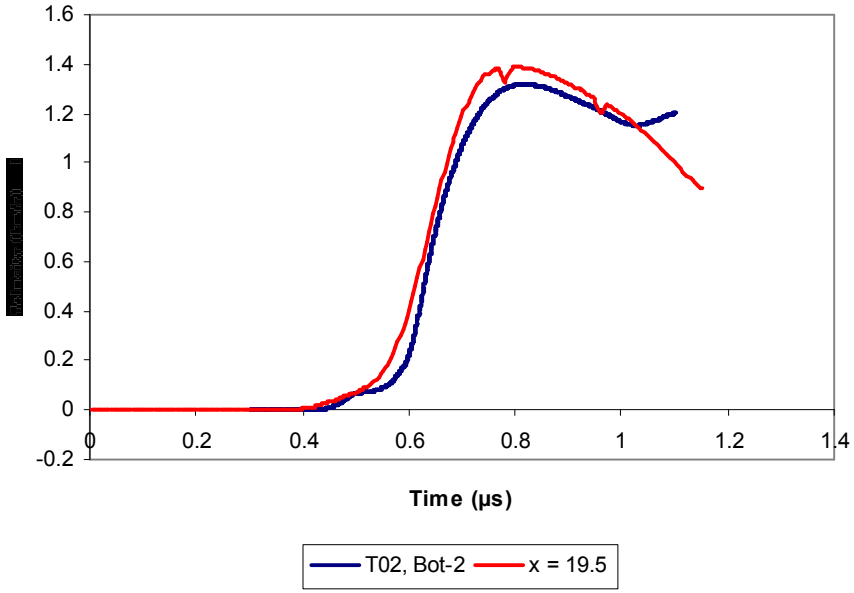


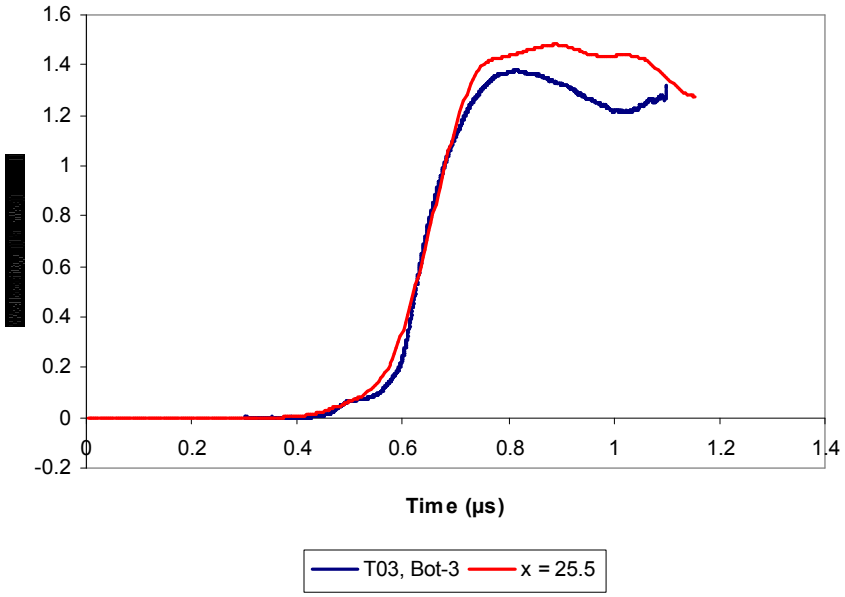


Reference Panel: free-surface velocity curves

Previous results (lower resolution)







Simulation and experimental free-surface velocity as a function of time at three positions along the length of the panel : 13.5mm, 19.5mm and 25.5mm.
Reference panel: 15mm x 35mm x 2.5mm

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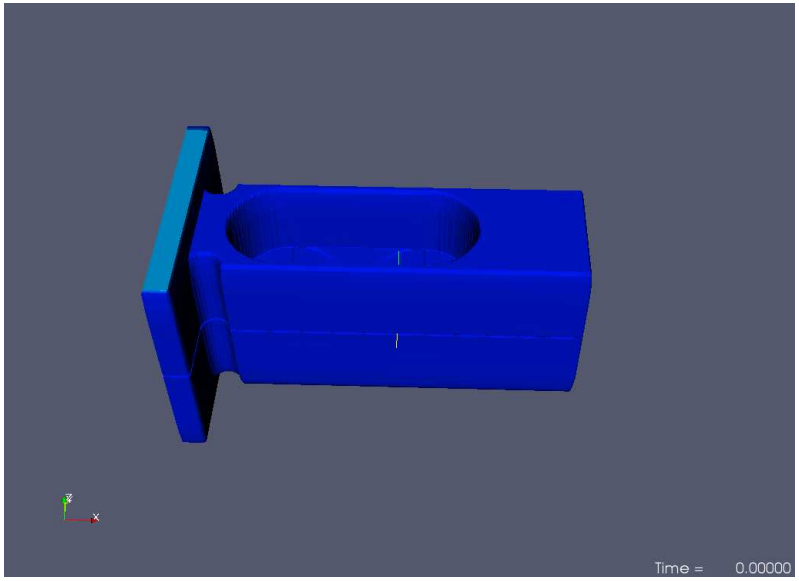
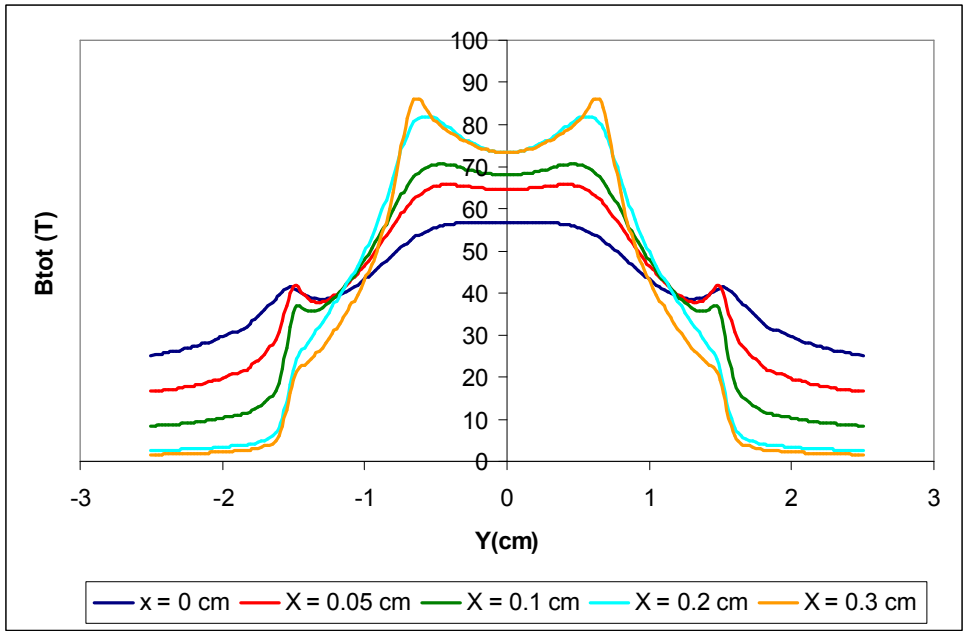
VELOCE Simulations: Panel Area



Input current distribution for panel simulation



Resolution :

- 0.25 mm in X and Y direction (panel plane)
- 0.0425 mm graded to 0.25 in z direction

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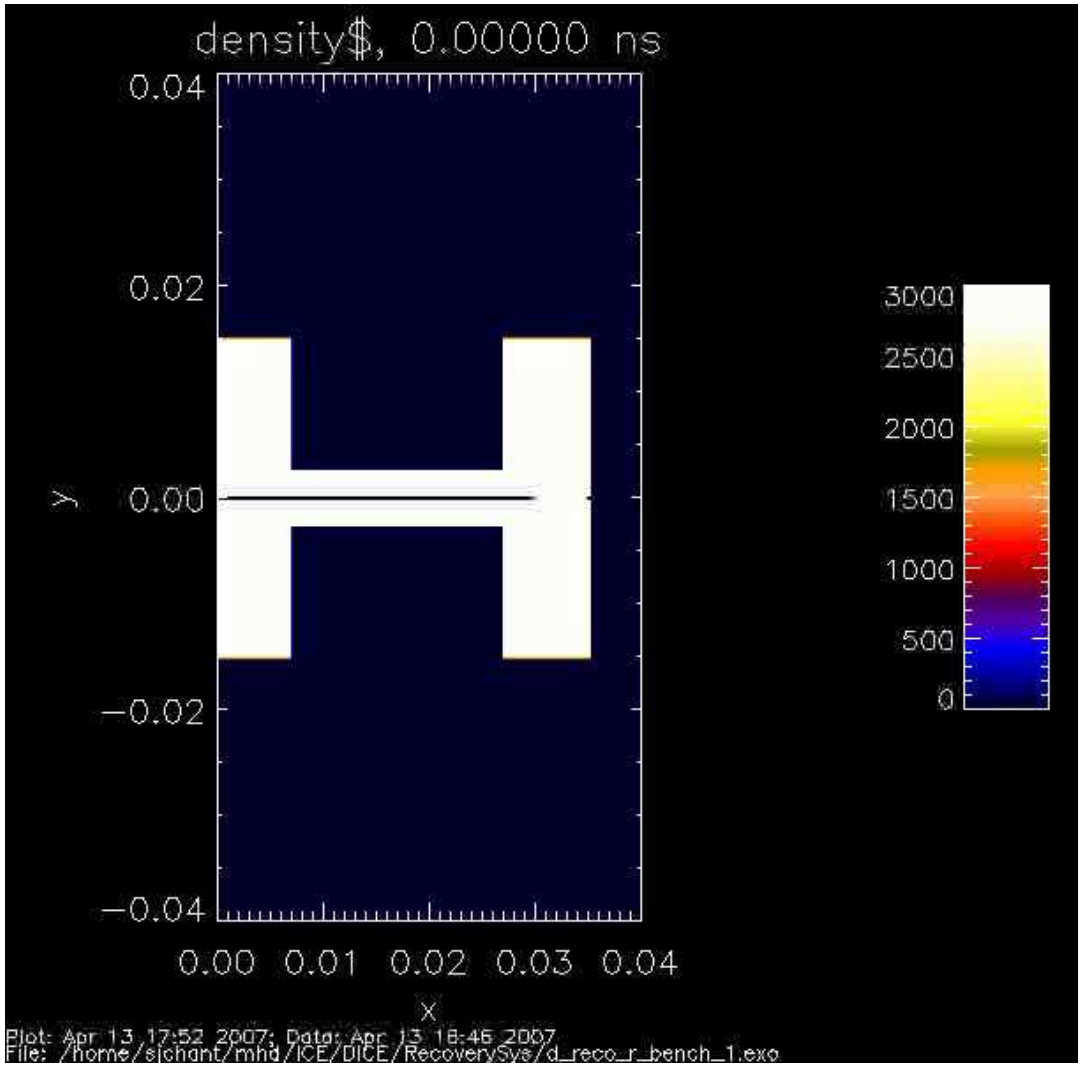
VELOCE Simulations: Panel Area

Density profile as a function of time



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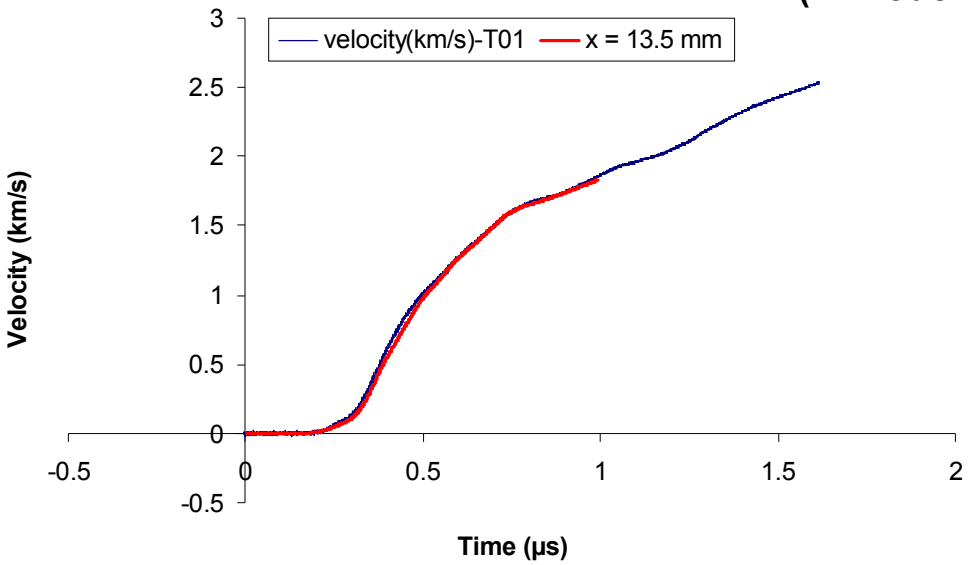
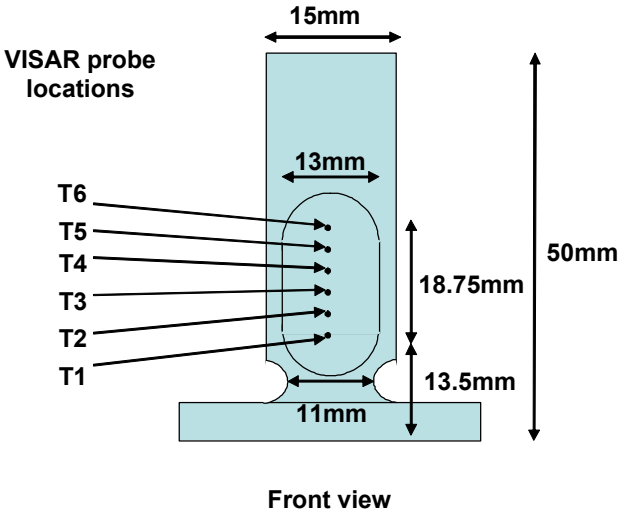
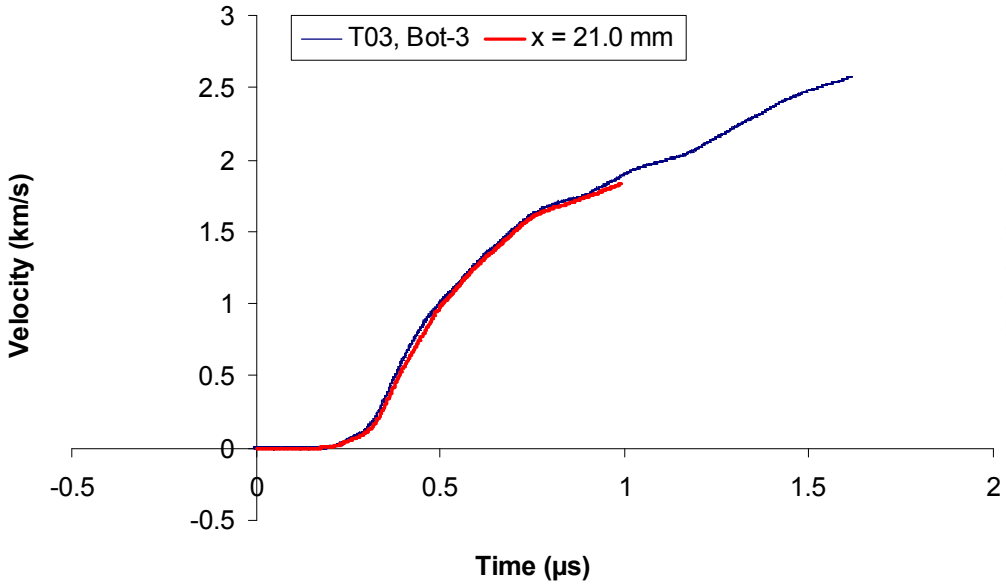
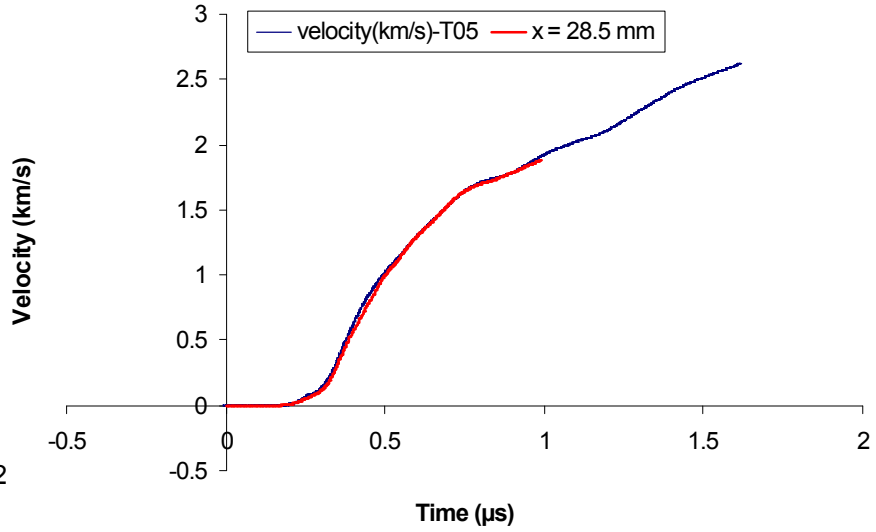
VELOCE Simulations Benchmarking

Comparison of measured and calculated free surface velocity at different probe positions
(– model – experiment)









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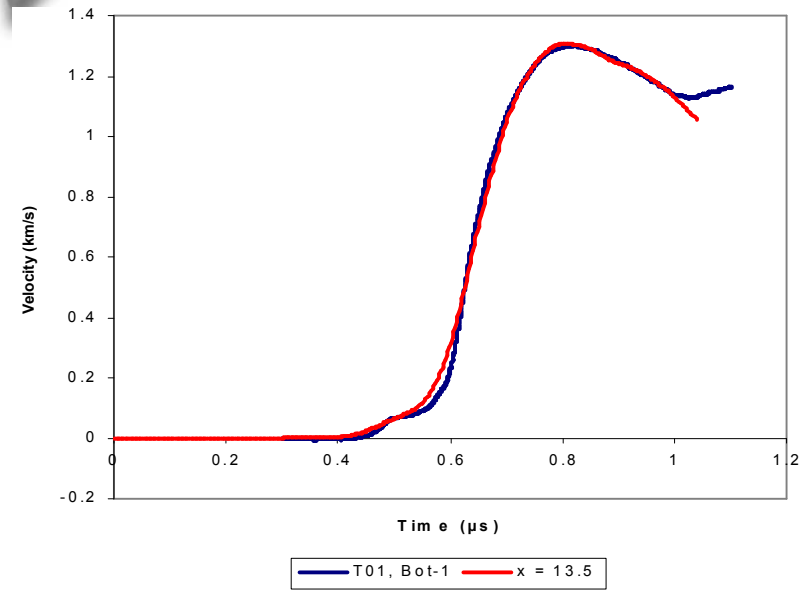
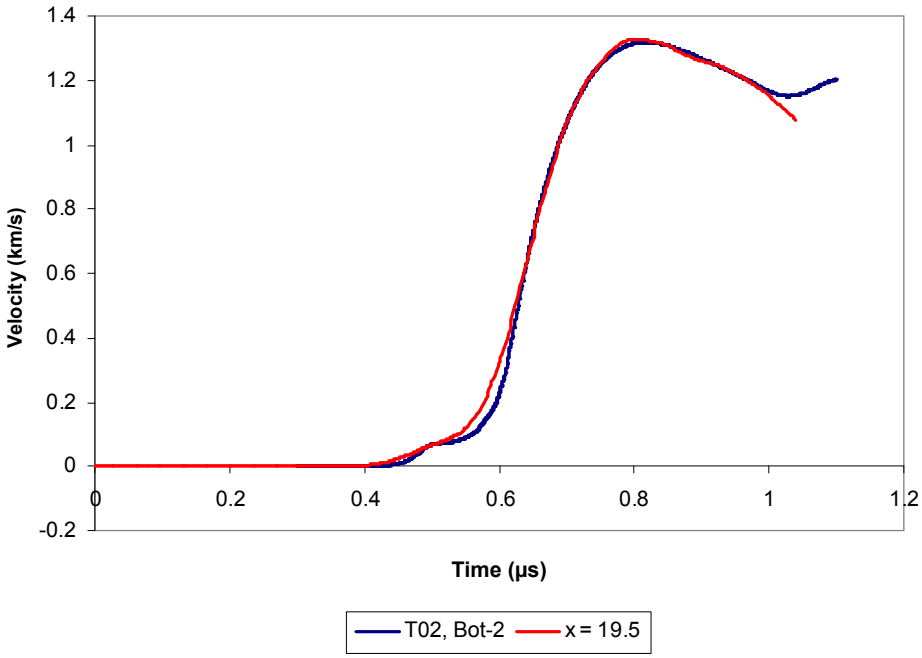
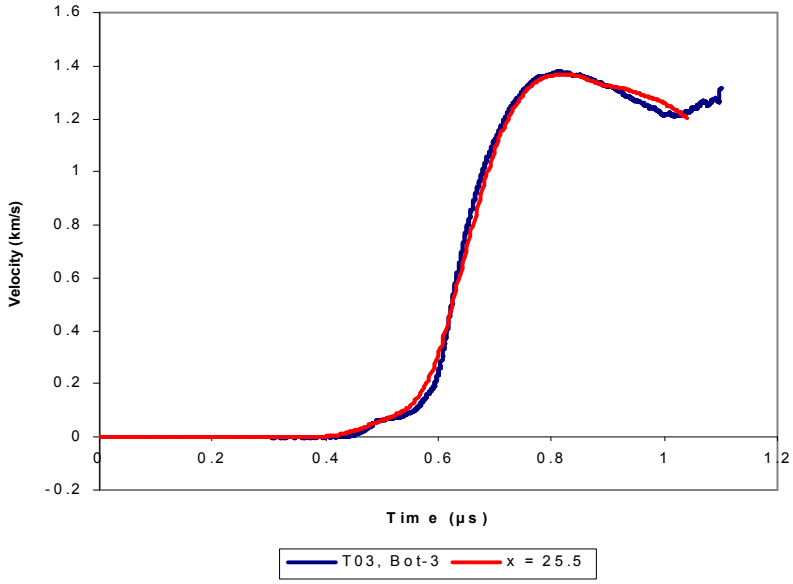
VELOCE Simulations: Panel Area

Reference Panel: free-surface velocity curves







Simulation and experimental free-surface velocity as a function of time at three positions along the length of the panel : 13.5 mm, 19.5 mm and 25.5 mm.

Reference panel: 15 mm x 35 mm x 2.5 mm

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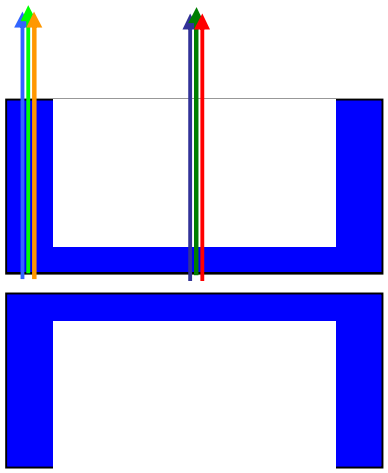
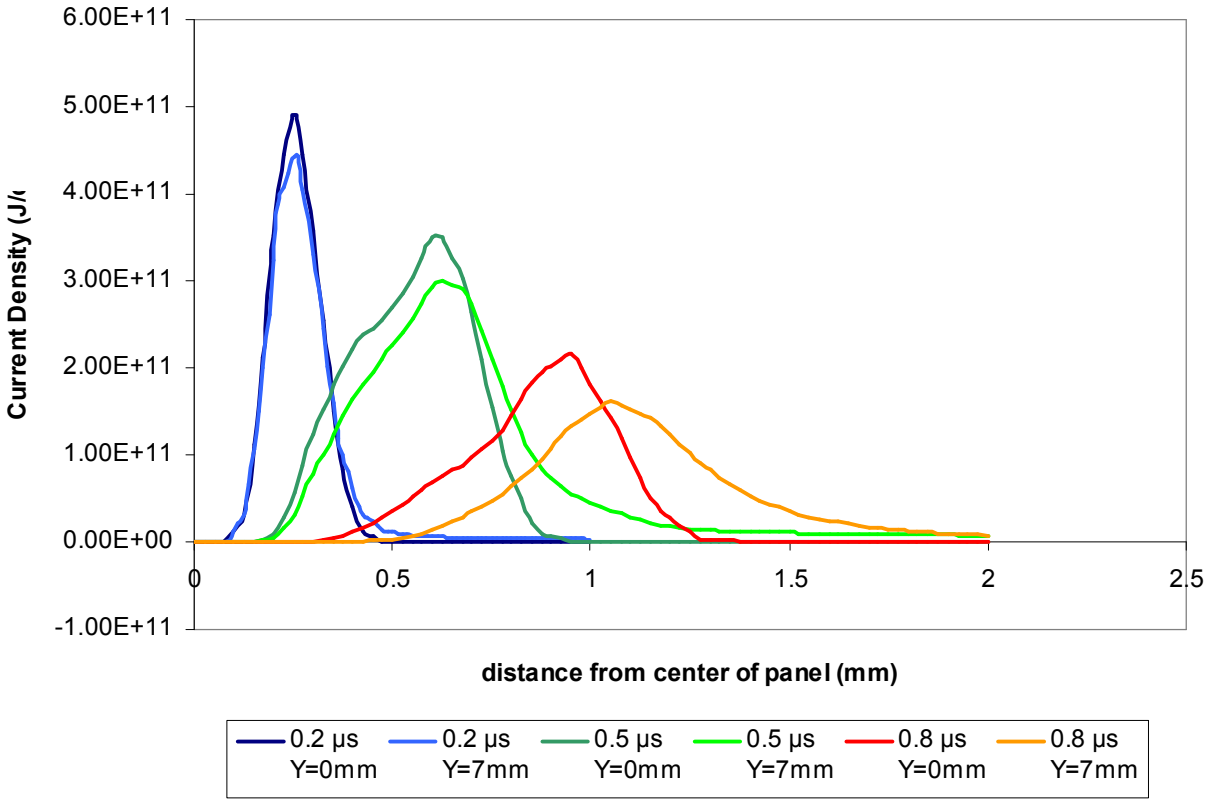
VELOCE Simulations: Load Area Current Diffusion in the Panel





Total current density across the thickness of the panel at 2 cm from the bottom of the panel at three different times: 0.2 μs (blue curves), 0.5μs (green curves) and 0.8 μs (red-orange curves). The current density is estimated in the center of the panel width (Y=0 mm) and at the edge of the panel width (Y=7mm).

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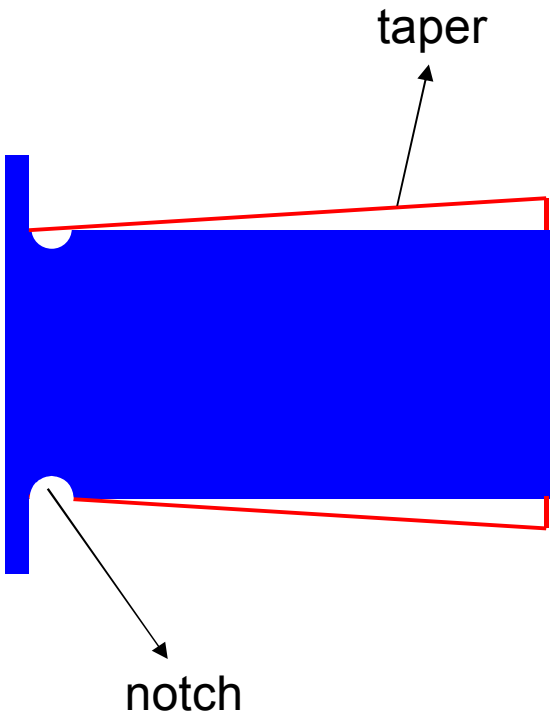
DICE Simulations: Panel Area

- Reference panel: 15mm x 35mm x 2.5mm
  - Different notch size
  - Different taper
- Long panel: 15mm x 50mm x 1mm
  - Different notch size
  - Different taper
- Reference panel: 20mm x 45mm x 1mm
  - Different notch size
  - Different taper
- Tilted panel



Reference: T. Ao, J.R. Asay, S. Chantrenne, M.R. Baer, and C.A. Hall, 'A compact strip-line pulse power generator for isentropic compression experiments'

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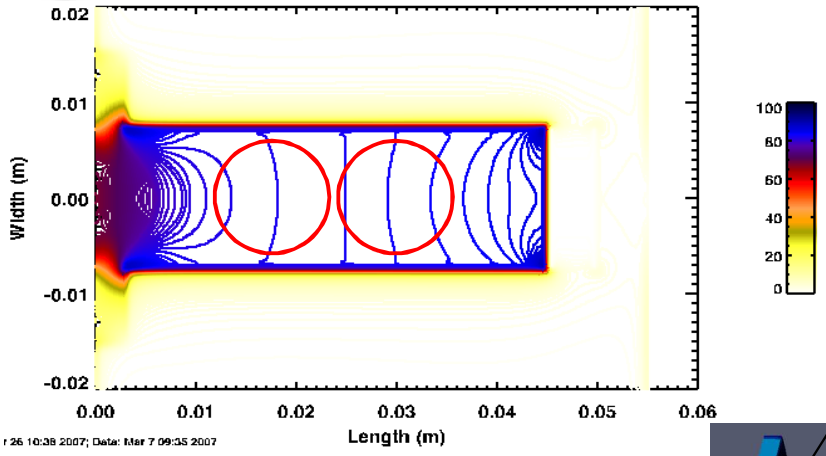
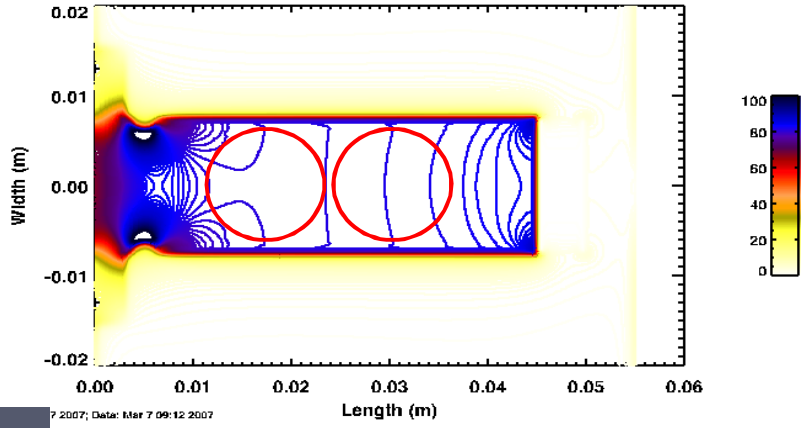
Simulation Results – Long Panel

notch size variation - R = 1.5mm, 1.0mm, 0.5mm and no notch

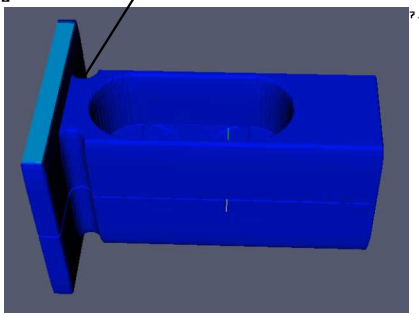
15mmx50mm panel, no notch, B at t=0.2μs



15mmx50mm panel, notch r=1.0mm, B at t=0.2μs

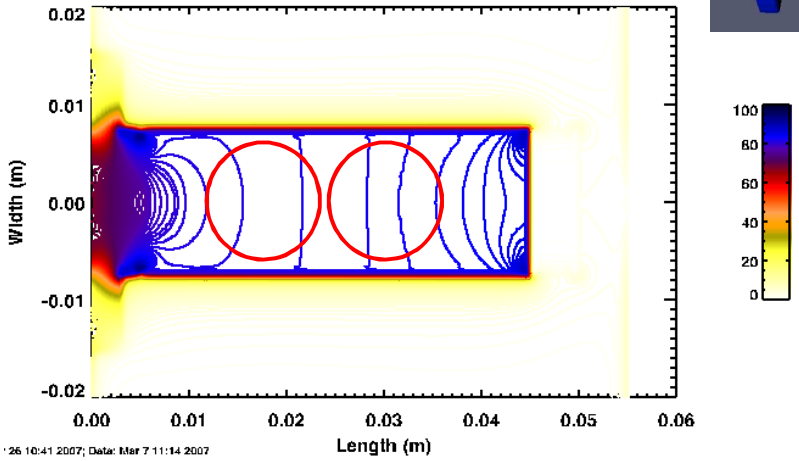


notch

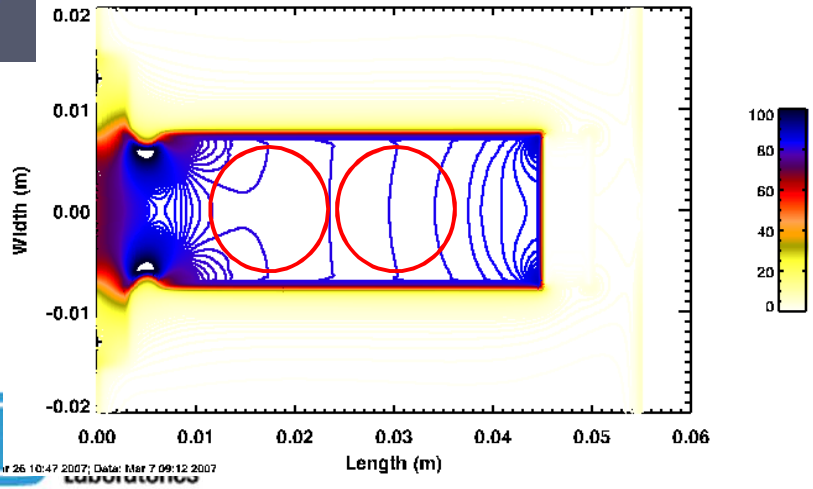


Resolution: ~0.5 % between levels

15mmx50mm panel, notch r=0.5mm, B at t=0.2μs

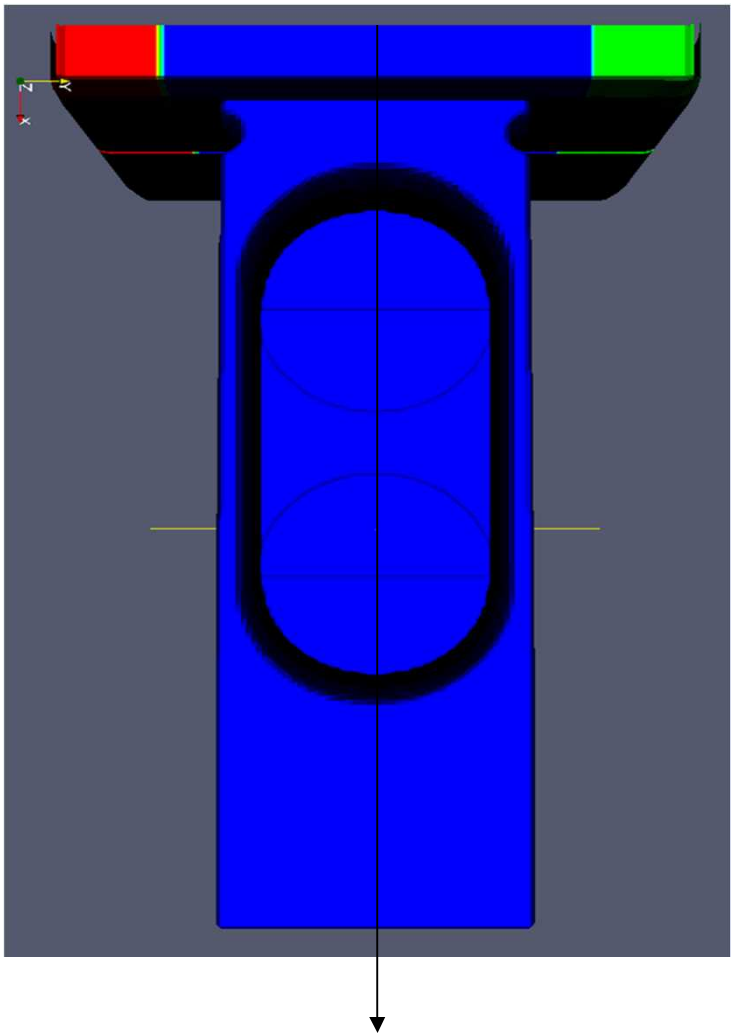


15mmx50mm panel, notch r=1.5mm, B at t=0.2μs

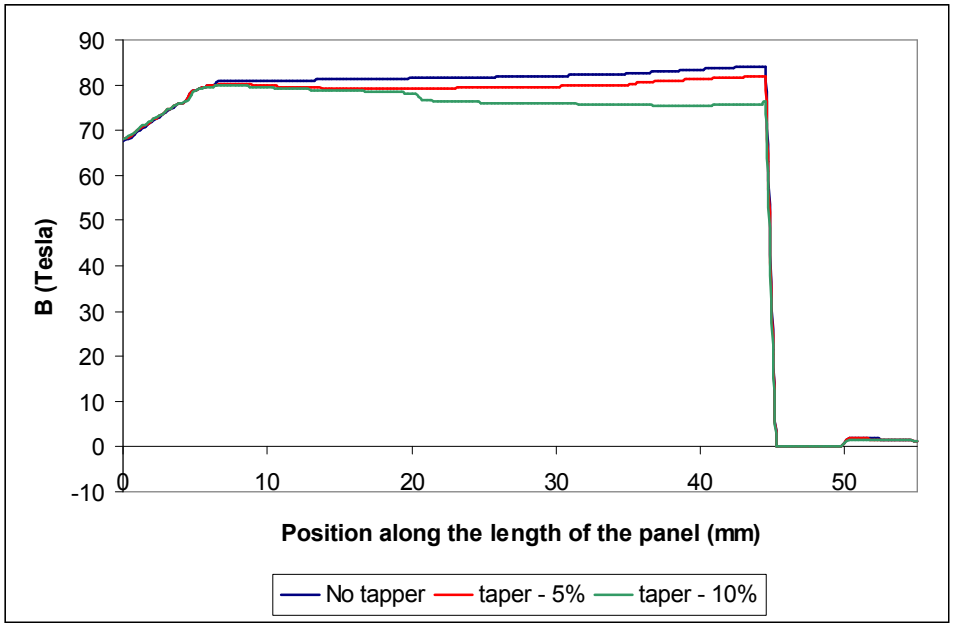


Tapered Long Panel: 0% - 5% - 10%

Taper = 5%



B (T) at the edge of the panel between the two panels. B is directly proportional to Jtot.



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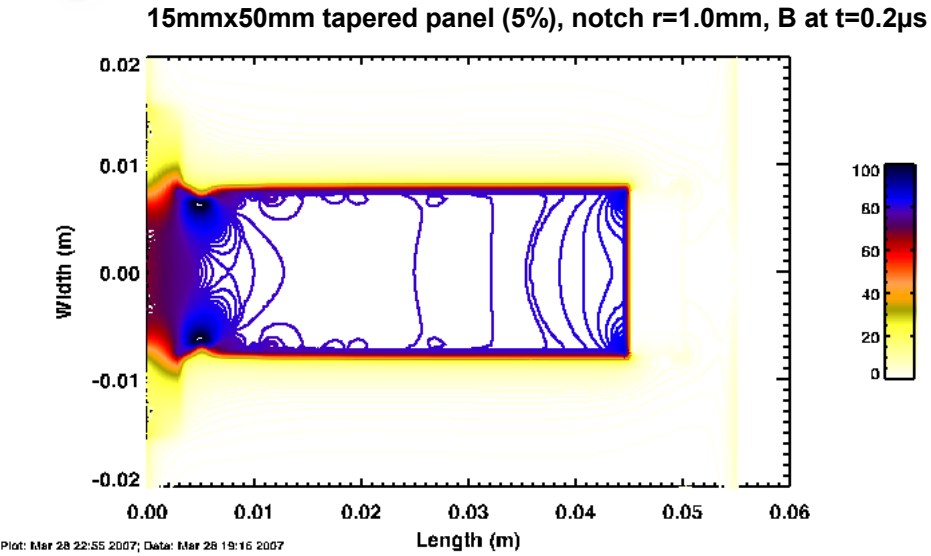
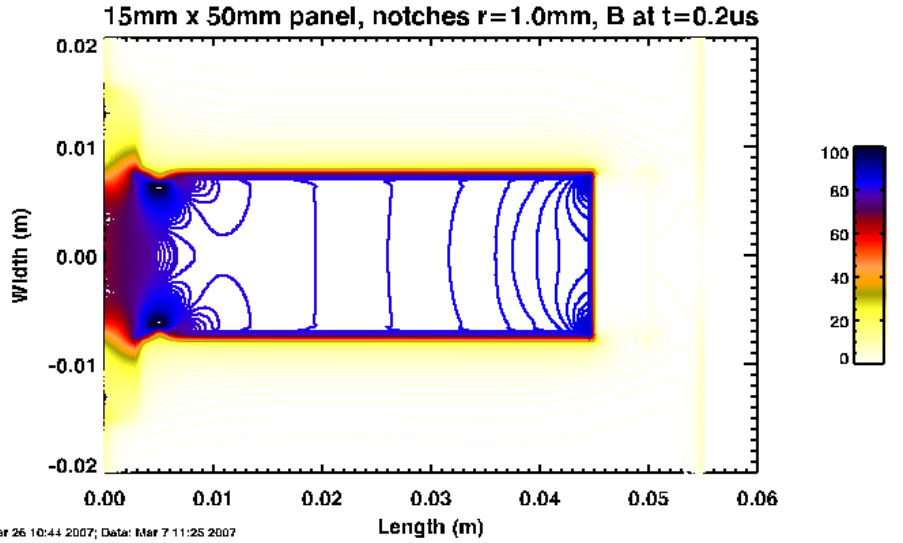
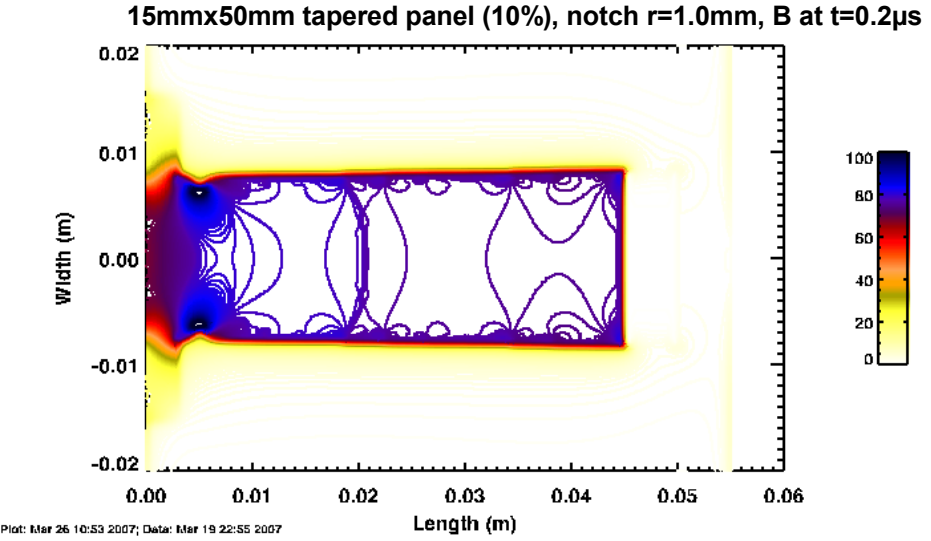
Tapered Long Panel: 0% - 5% - 10%







Resolution: 0.5 % between levels
The contour irregularities at the edges are due to the mesh that is not parallel to the edge

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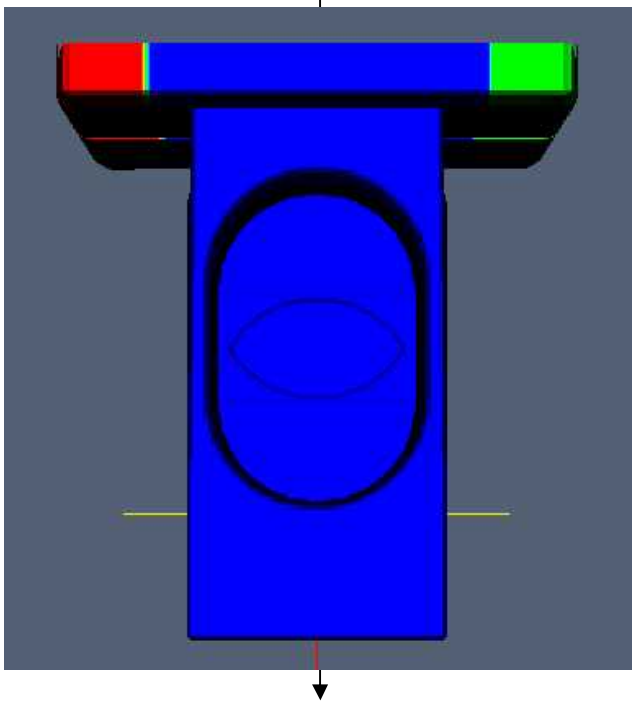
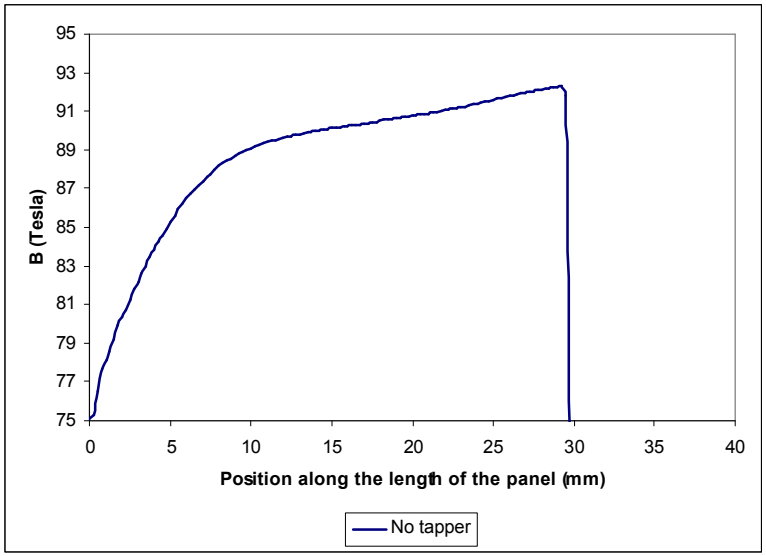
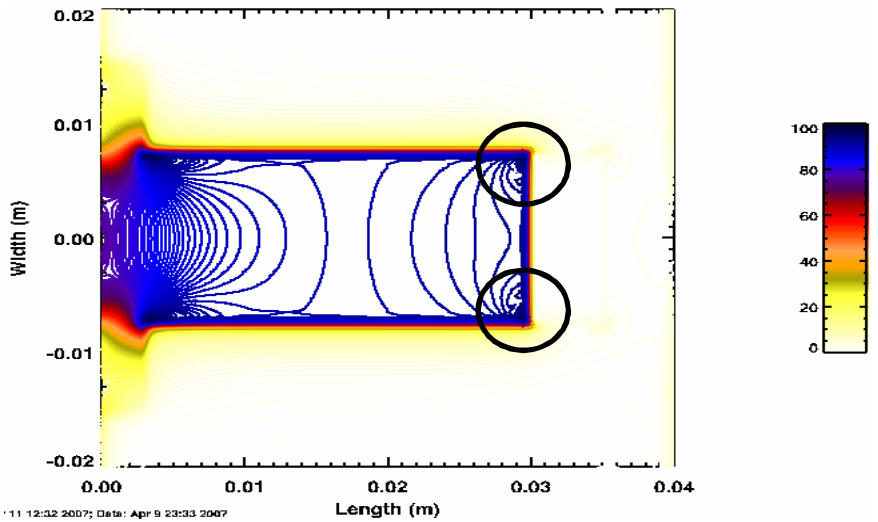
Current density non uniformity at the end of the panel





Problem: B at the edge of the contact is about 15% higher than in the center, causing B to increase by about 3% along the usable part of the panel → need to reduce/eliminate the hot spot at the end of the contact by modifying the contact area of the panel



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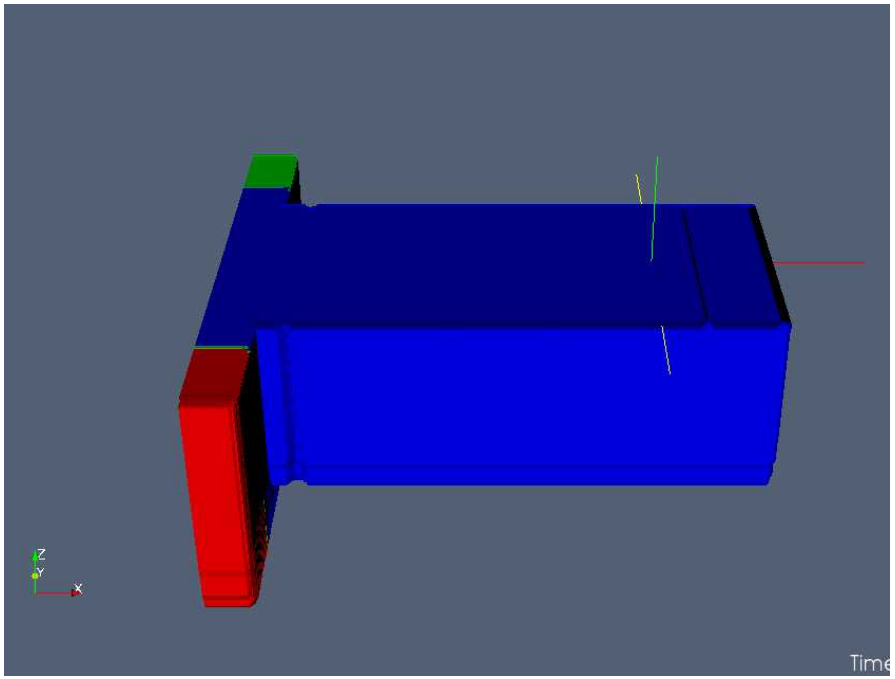
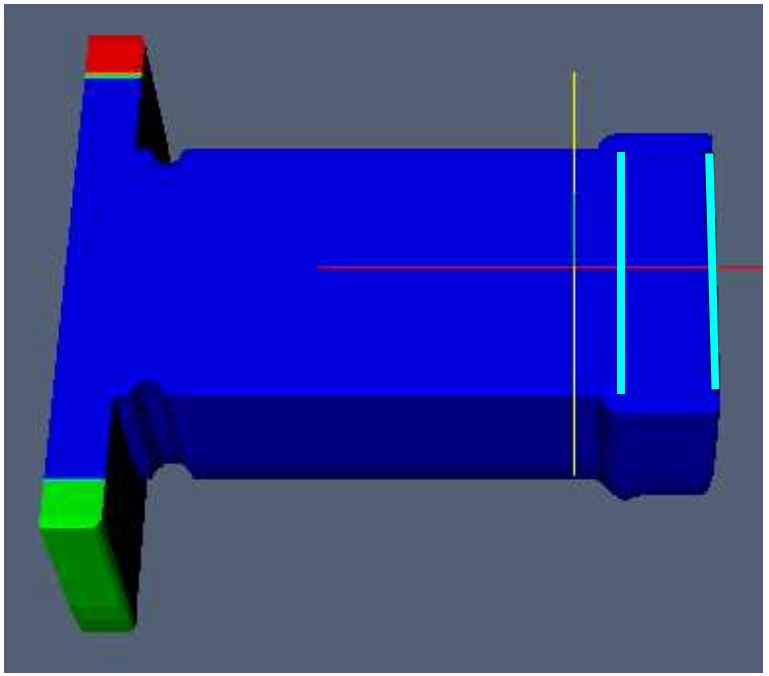
B (T) at the edge of the panel between the two panels. B is directly proportional to Jtot.

Proposed modification

Original panel



Modified panel



Bottom panel with contact. Contact does not show well because we are limited by the resolution of the simulation.

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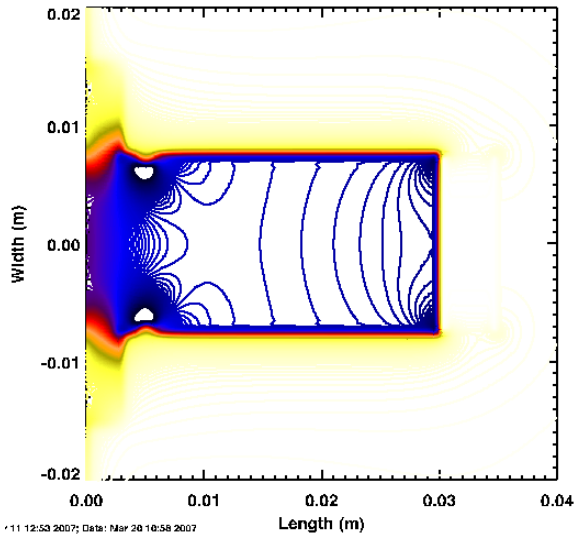
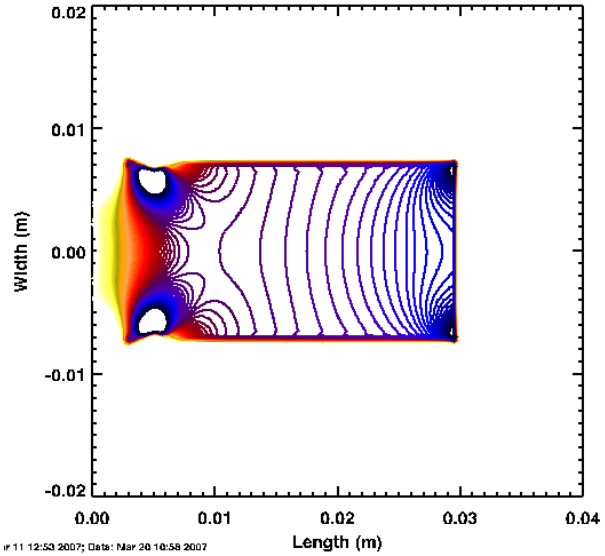
Preliminary Results

Original panel

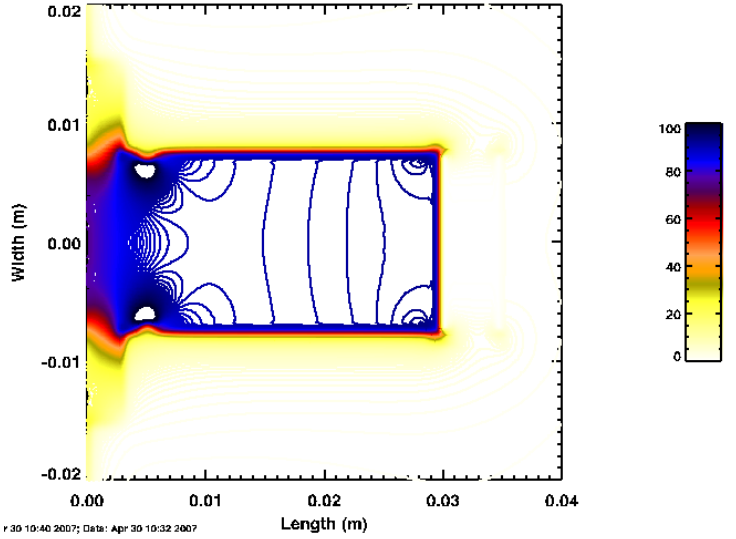
15 mm x 35 mm, 1 mm notch
original panel, B at 0.2 μs



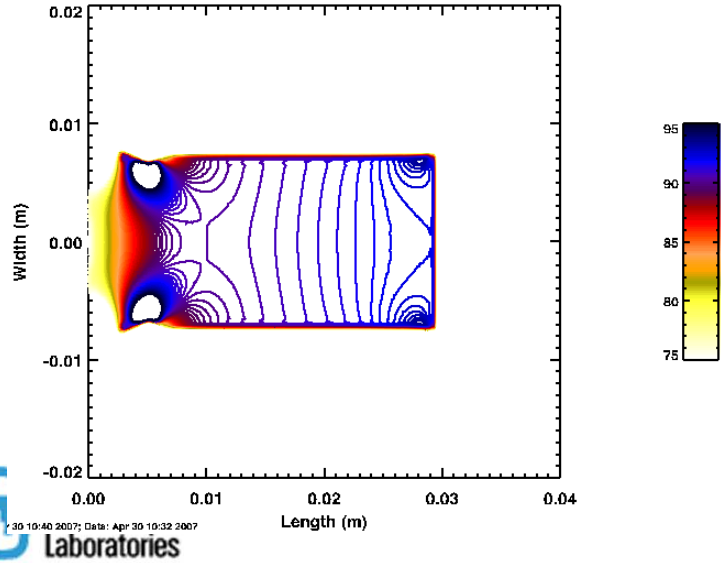


Modified panel

15 mm x 35 mm, 1 mm notch
extended panel in contact area, B at 0.2 μs



Resolution:
Top plots: 0.45 %
Bottom plots: 0.25%



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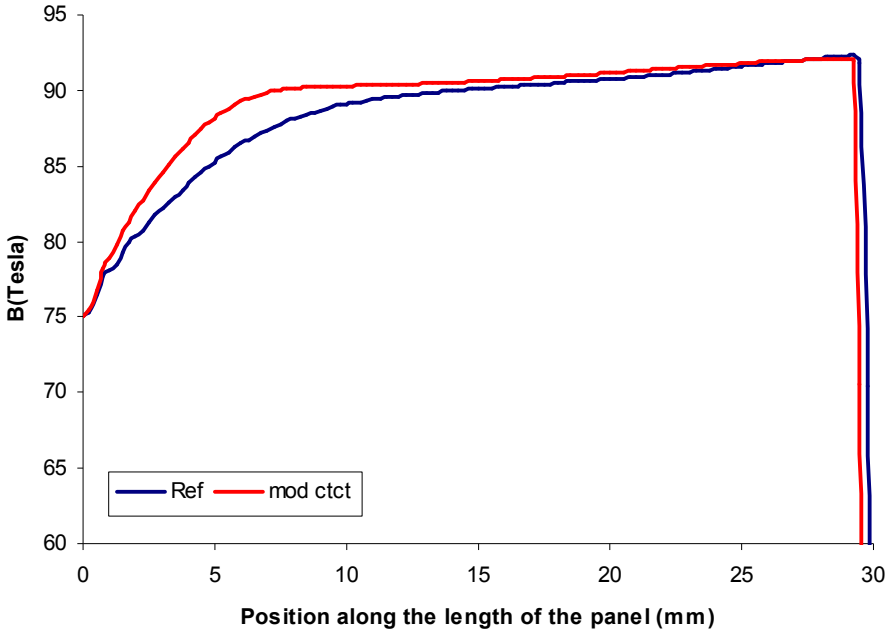
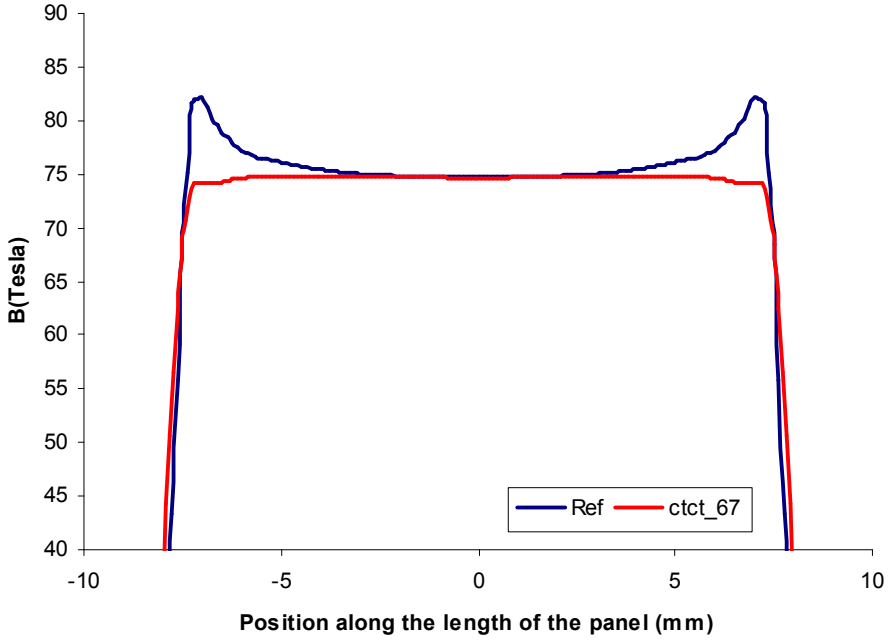
Results





B at the edge of the panel between the two panels.

B along the width of the panel at the edge of the contact between the two panels.

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Conclusions

- 3D simulations of VELOCE allow us to:
  - understand the current density distribution across the sample panel for a wide variety of panels thereby increasing the uniformity of the current and improving measurement accuracy
  - design the optimum panel for a specific sample minimizing the number of shots required for a given sample
- The simulations reproduced experimental free-surface velocities very well; resolution is the only limitation in 3D

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Backup slides

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ALEGRA: a Magneto Hydrodynamic Code

- Arbitrary Lagrangian-Eulerian finite element 2-D and 3-D code
- Includes:
  - Magneto hydrodynamics (MHD)
  - Thermal conduction
  - Radiation transport
  - Material models
- Coupled with large number of material data (equation of states, opacity tables…)

References:
1. R. M. Summers, J. S. Peery, M. W. Wong et al., Int. J. Impact Engineering, 20 (1997), pp. 779–788.
2. J. S. Peery & D. E. Carroll, Computer Methods in Applied Mechanics and Engineering, 187 (2000), pp. 591–619.

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