DUNE TMS MAGNET

- ‘Short Stack’ Design
- Magnetic Flux Density Comparison

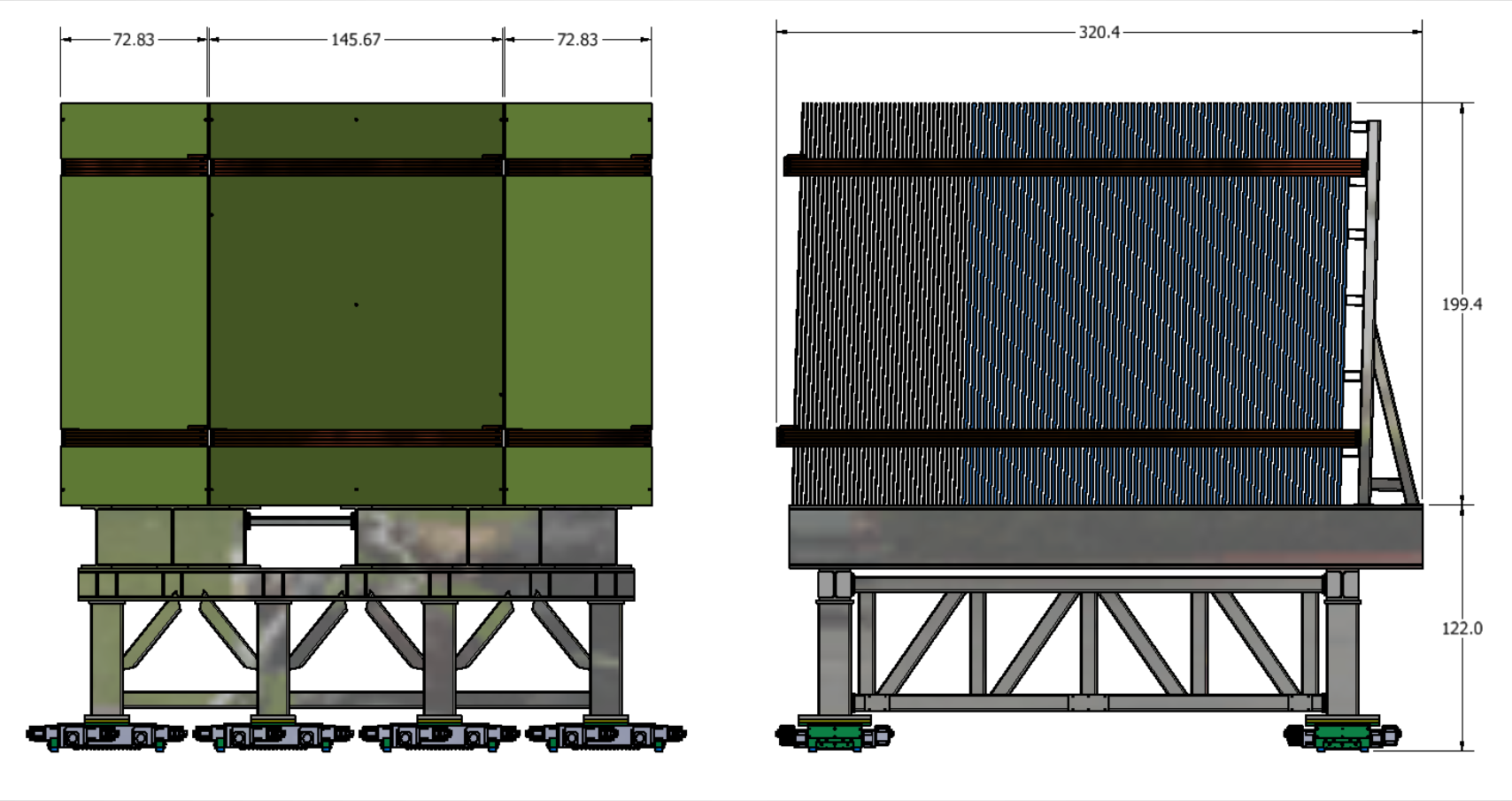
J. White, Guosheng Ye

Argonne National Laboratory
29 March 2023

SUMMARY

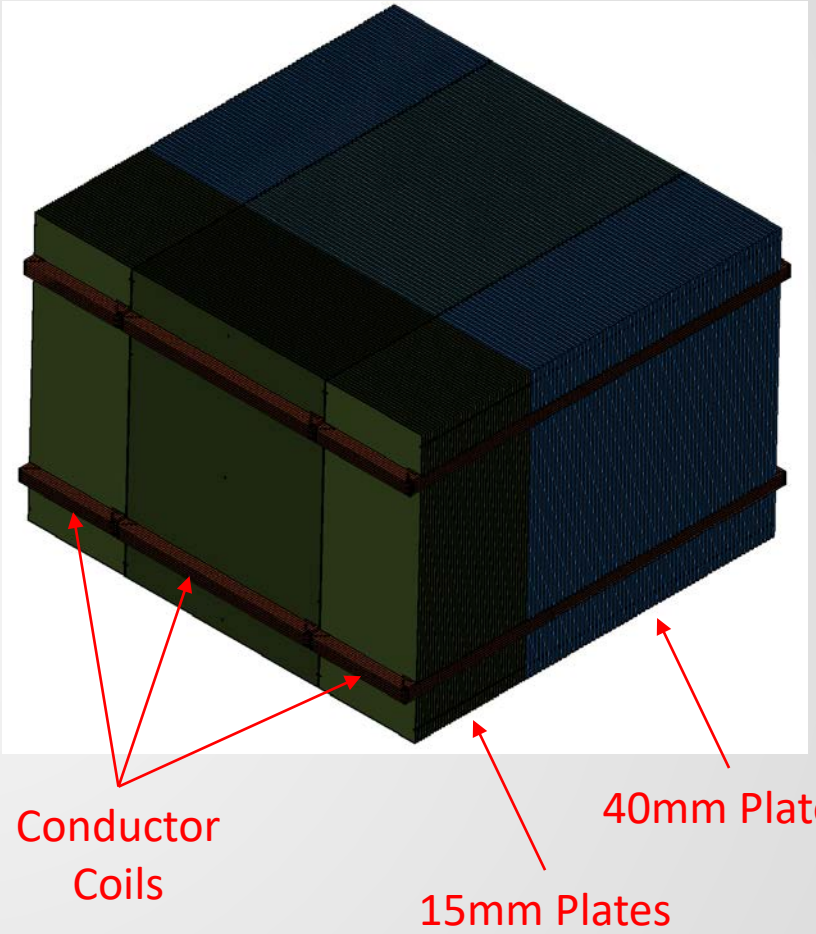
- Current magnet design review
- Proposed ‘short-stack’ magnet review
- Vertical plate dimension comparison
- Horizontal plate dimensions
- Guosheng’s ‘Magnetic Flux Density Comparison’

CURRENT MAGNET DESIGN



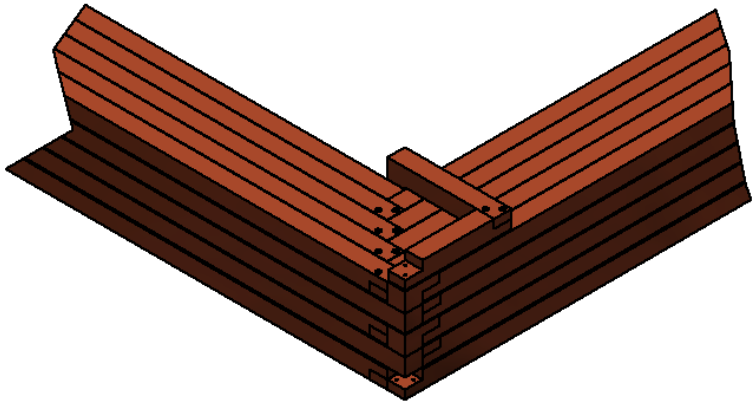
CURRENT MAGNET DESIGN

- 100 vertical layers of steel plates with a 40mm gap between layers for detector modules.
- Plates directly supported by structure at the bottom.
- 40 layers of 15mm plates in front.
- 60 layers of 40mm plates in back.
- Total approximate weight of steel plates is 958 Tons.

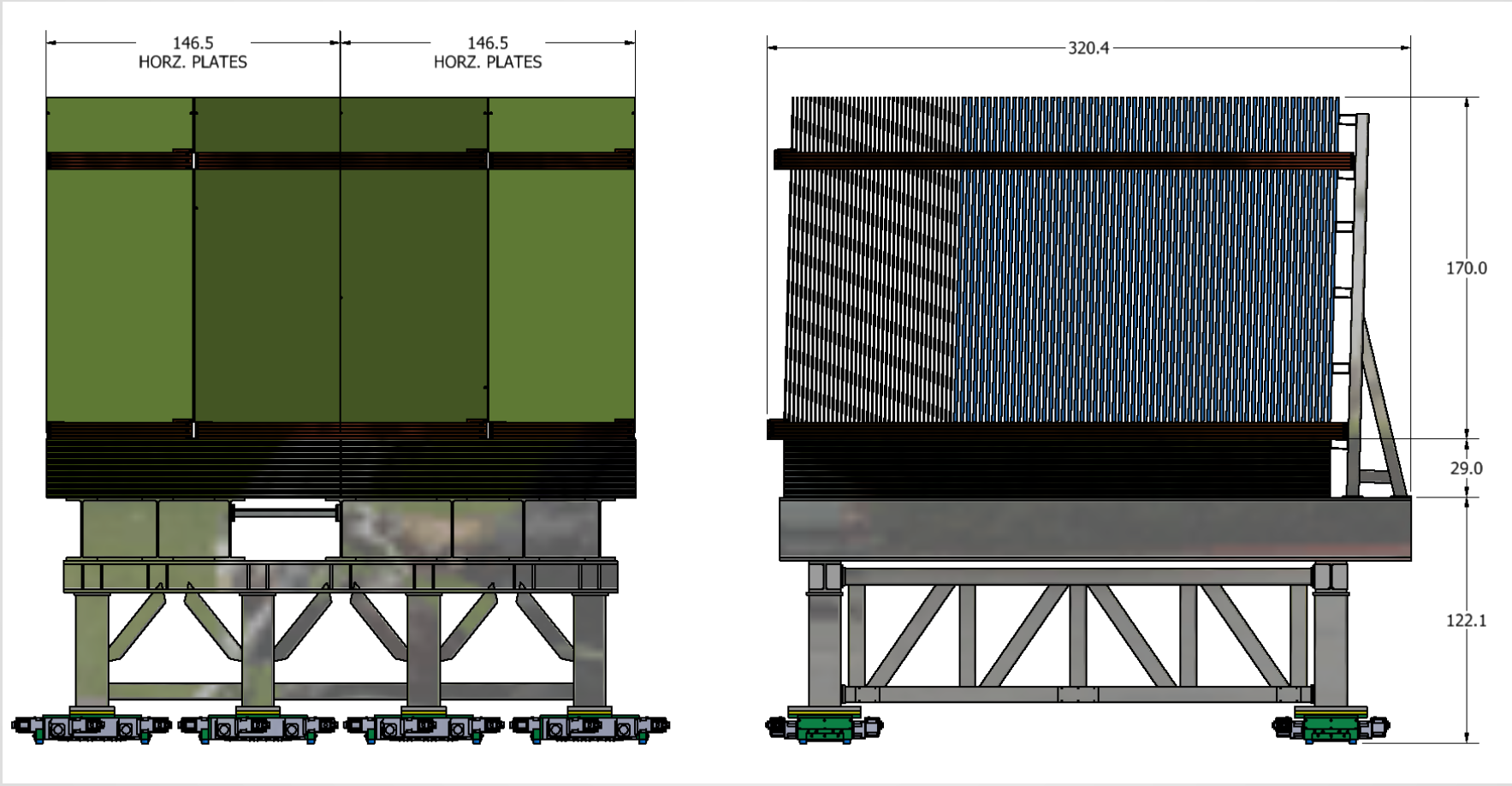


CURRENT MAGNET DESIGN

- Typical conductor coil for outside plates is shown.
-

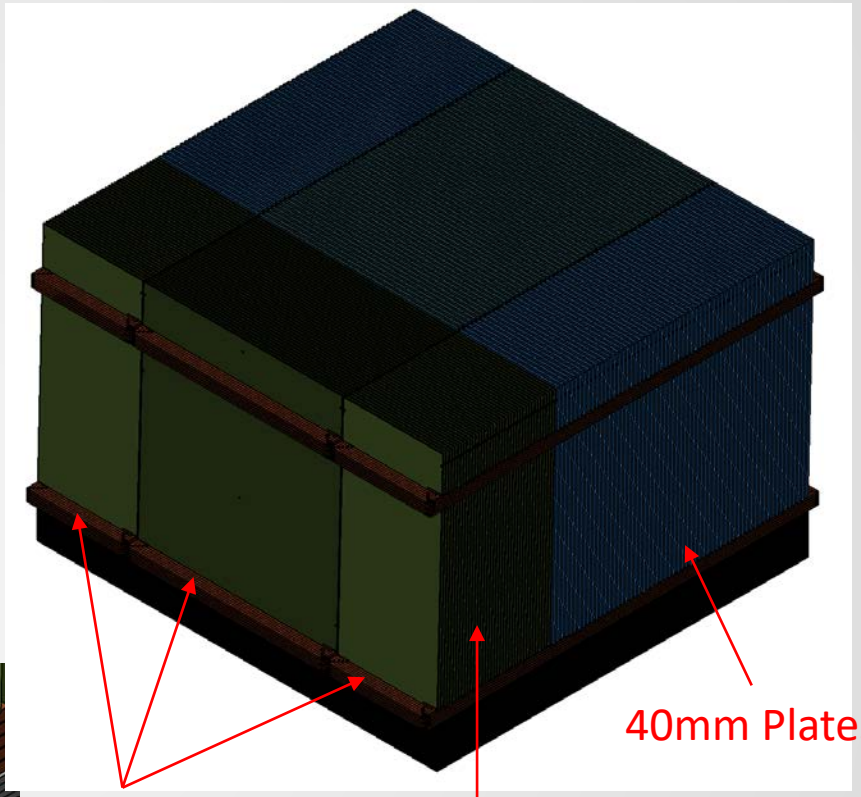


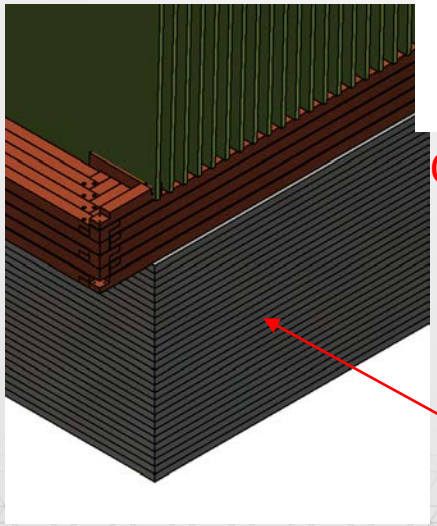
‘SHORT STACK’ MAGNET DESIGN



‘SHORT STACK’ MAGNET DESIGN

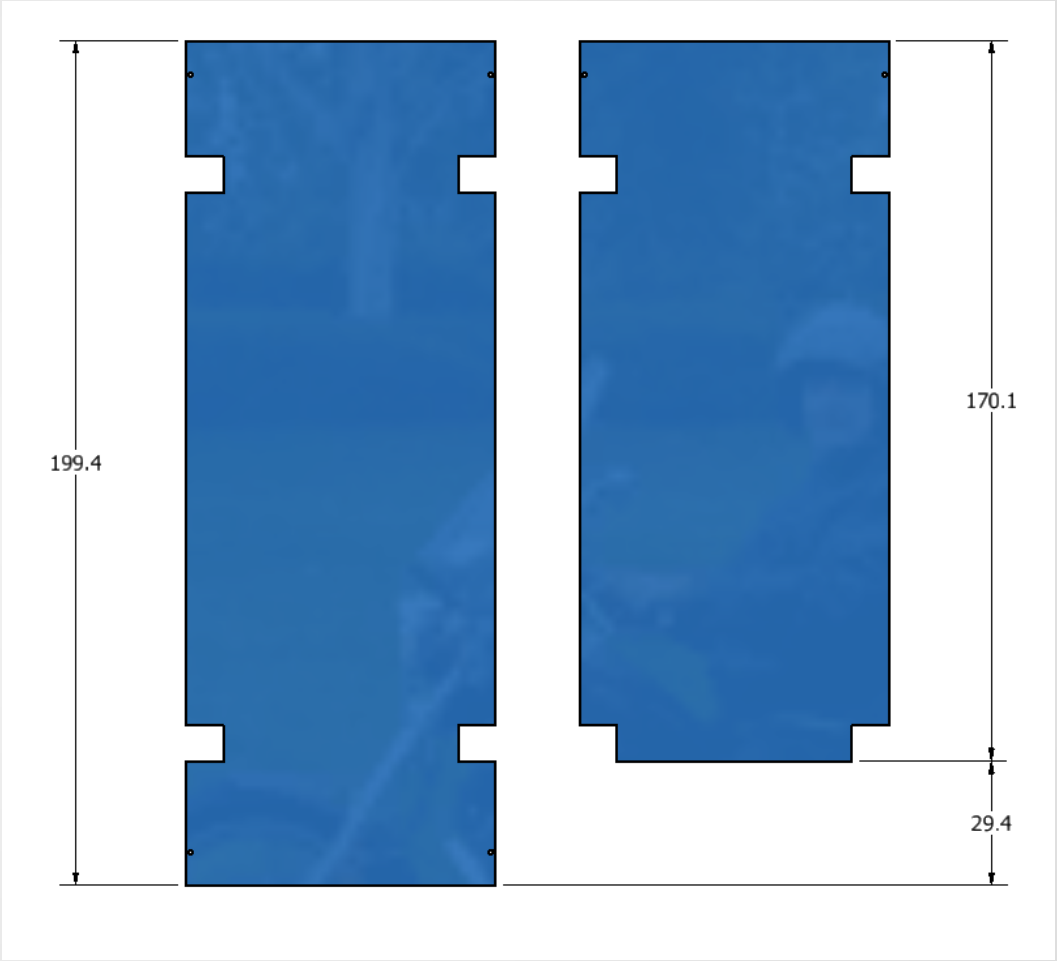
- Same number (100) and thickness of vertical layers of steel plates.
- The shorter vertical plates are supported by a stack of horizontal plates.
- 29 layers of 25.4mm thick horizontal plates are directly supported by structure at the bottom.
- Total approximate weight of steel plates is 1,140 Tons (vs. 958).
- Total approximate weight of vertical steel plates is 815 Tons.





VERTICAL PLATE DIMENSIONS

- ‘Short Stack’ plates were trimmed at bottom of lower coil notch.

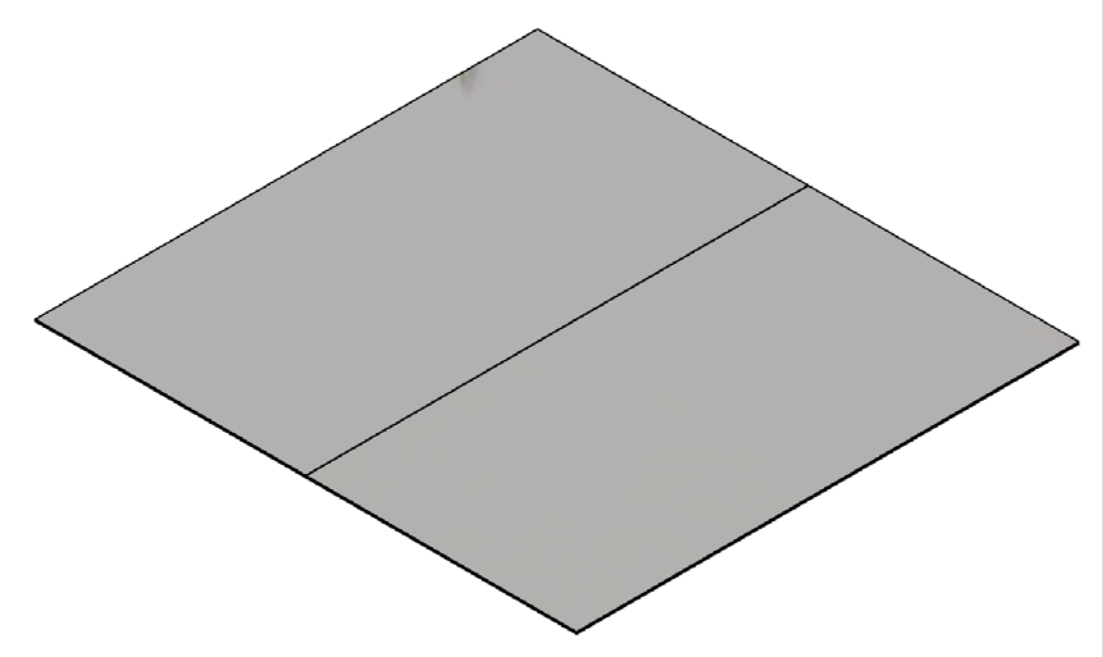


Current Design

‘Short Stack’ Design

HORIZONTAL PLATE DIMENSIONS

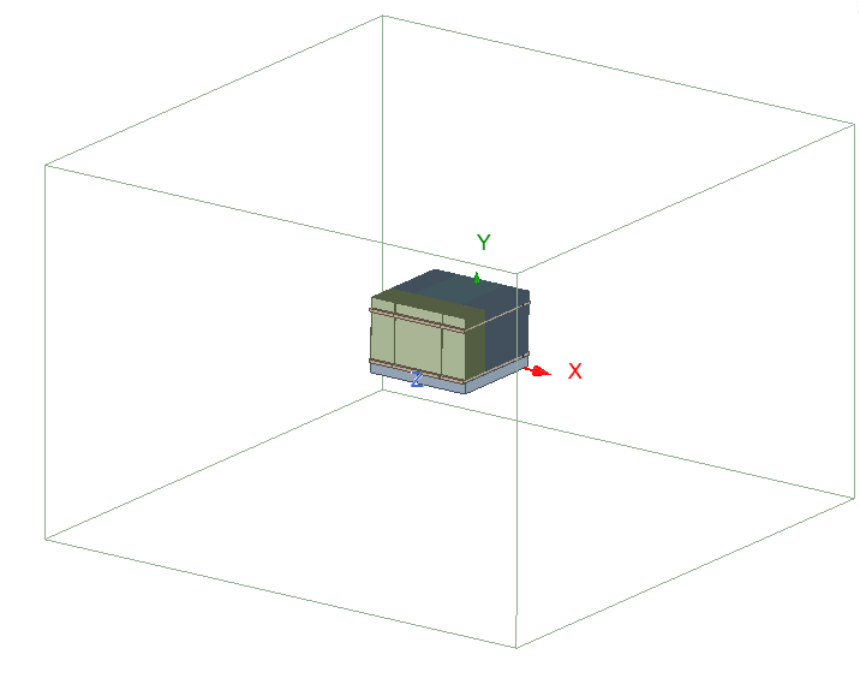
- First layer of horizontal plates is shown.
- Plates are 146.5 in x 272 in x 1 in thick.
- Plates are just over 12 ft wide so can most likely be shipped on a flatbed semi.
- Gap between plates in magnetic analysis is 0.20 in.



MAGNETIC FLUX DENSITY RESULTS COMPARISON

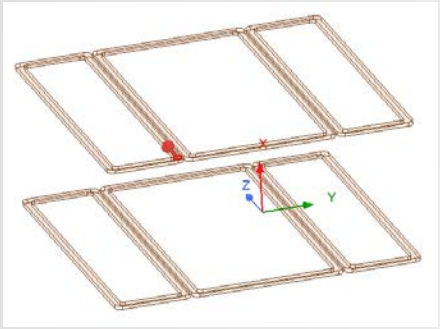
Guosheng Ye

MODEL INFORMATION

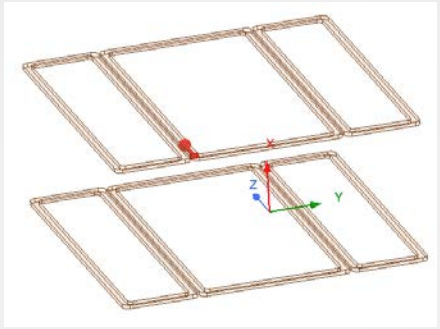


Green/gray: Minos steel plates
Brown: Bronze bars
inside frame: computation domain, plates + bars + air
Padding: 200%

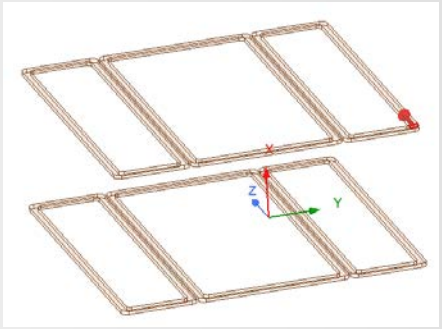
EXCITATION INFORMATION



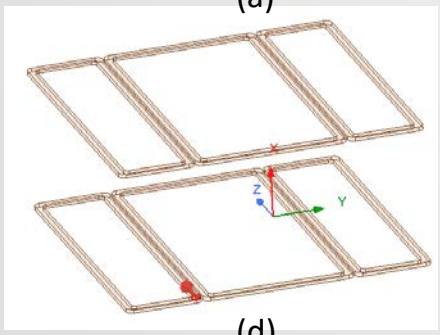
(a)



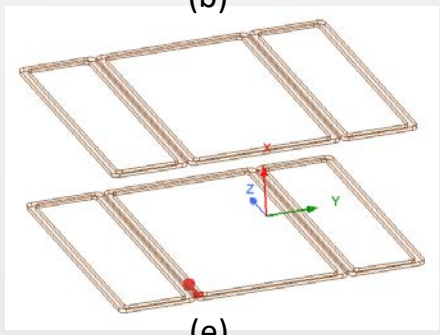
(b)



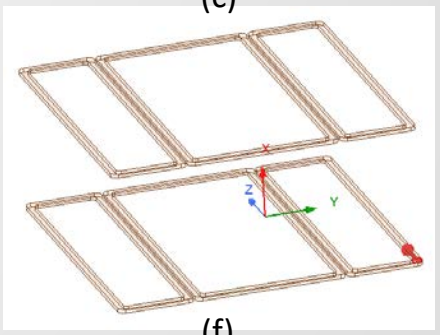
(c)



(d)



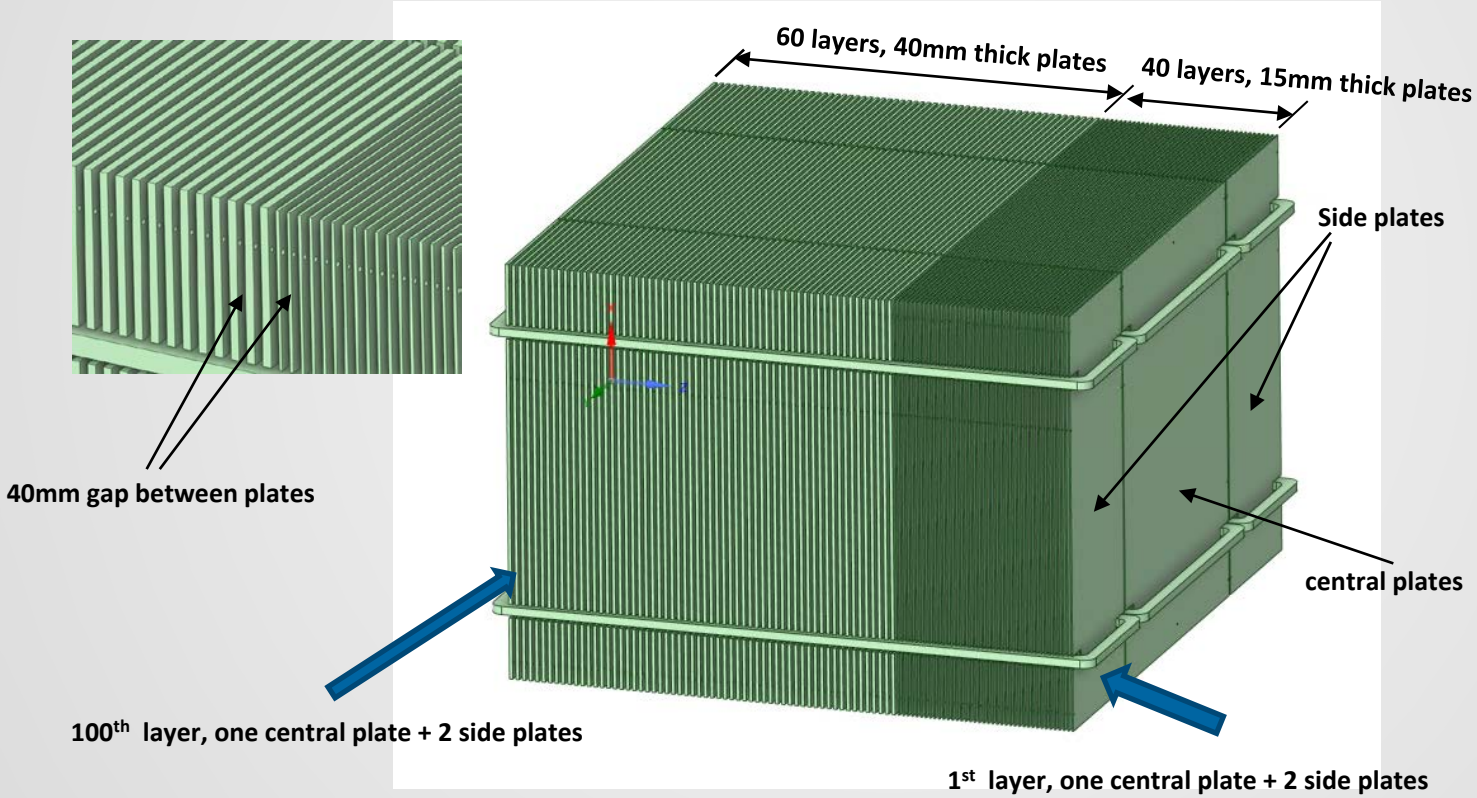
(e)



(f)

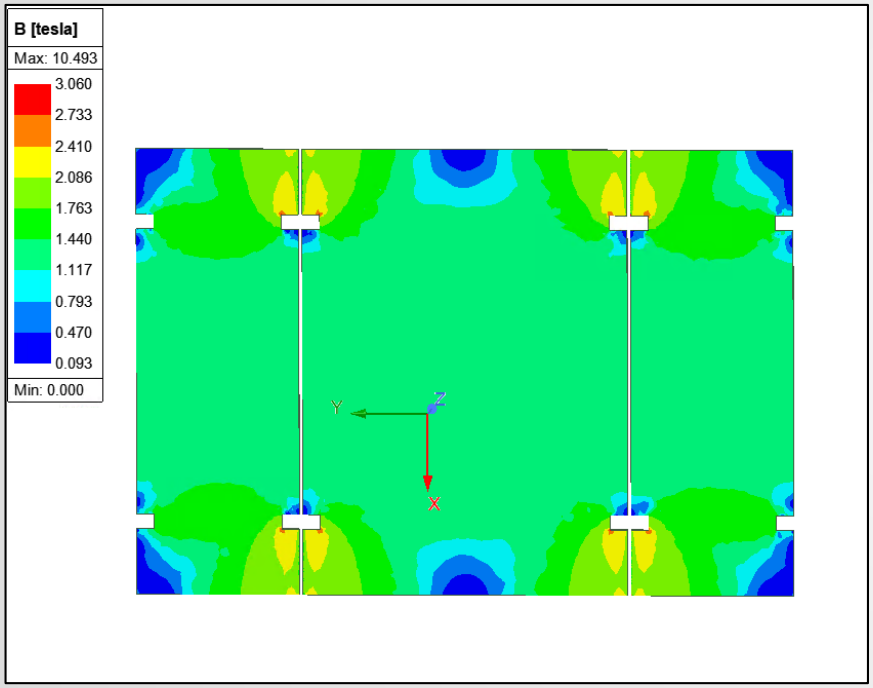
Current = 30,000A

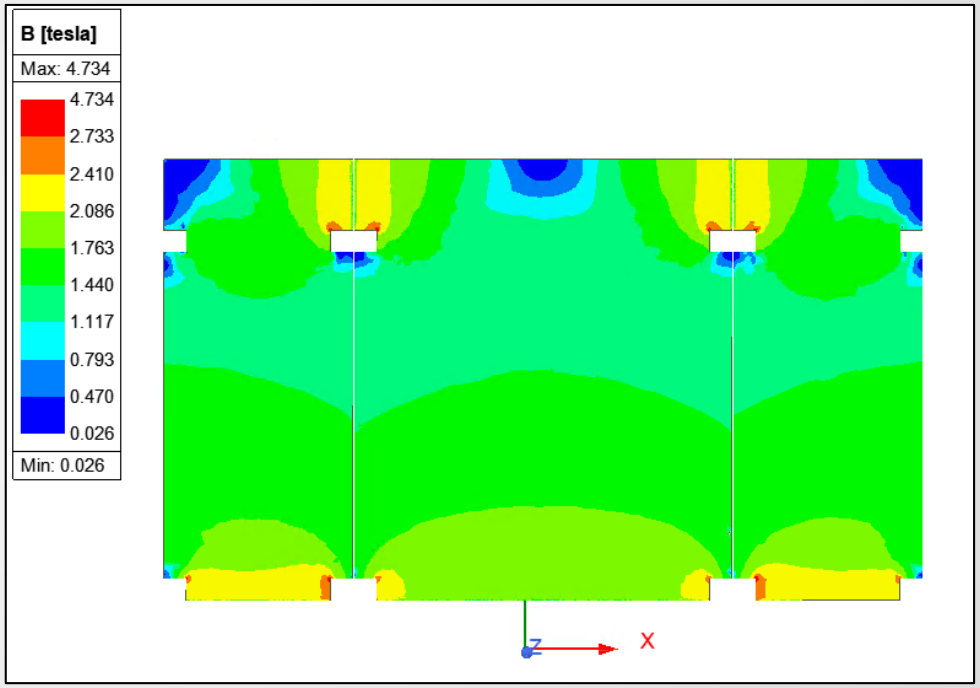
LAYERS OF INTEREST



“B” distribution on the 20th 15mm thick plate

(Magnitude)





(a)

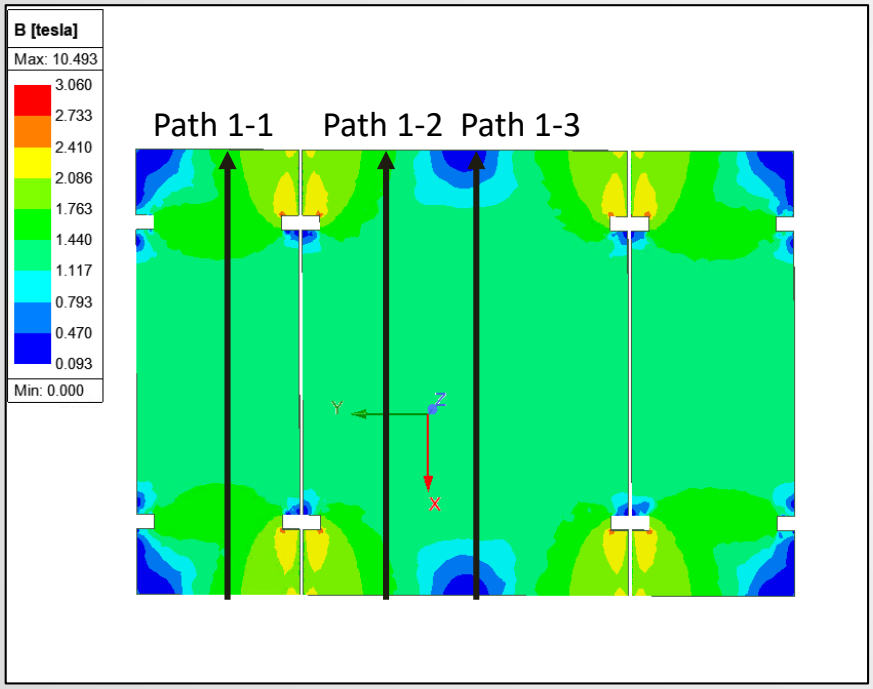
Old

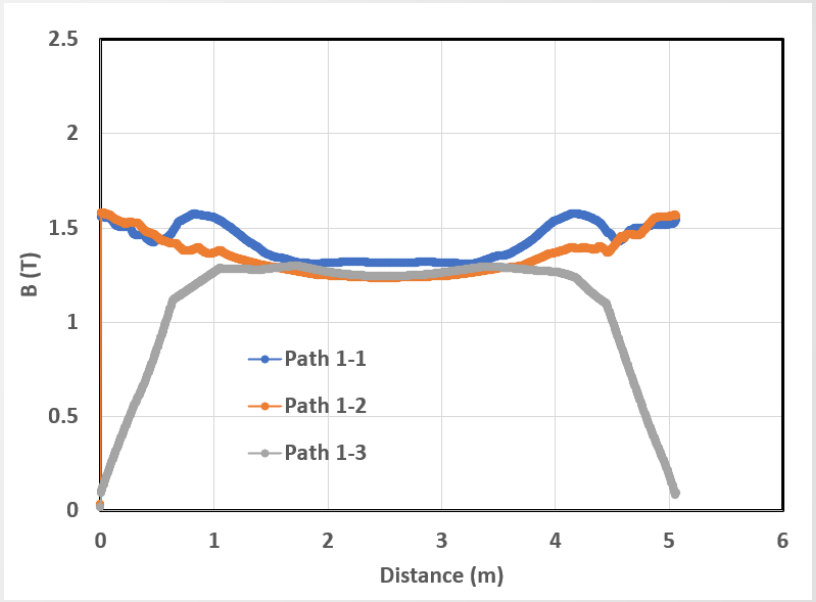
(b)

New

“B” ALONG PATHS

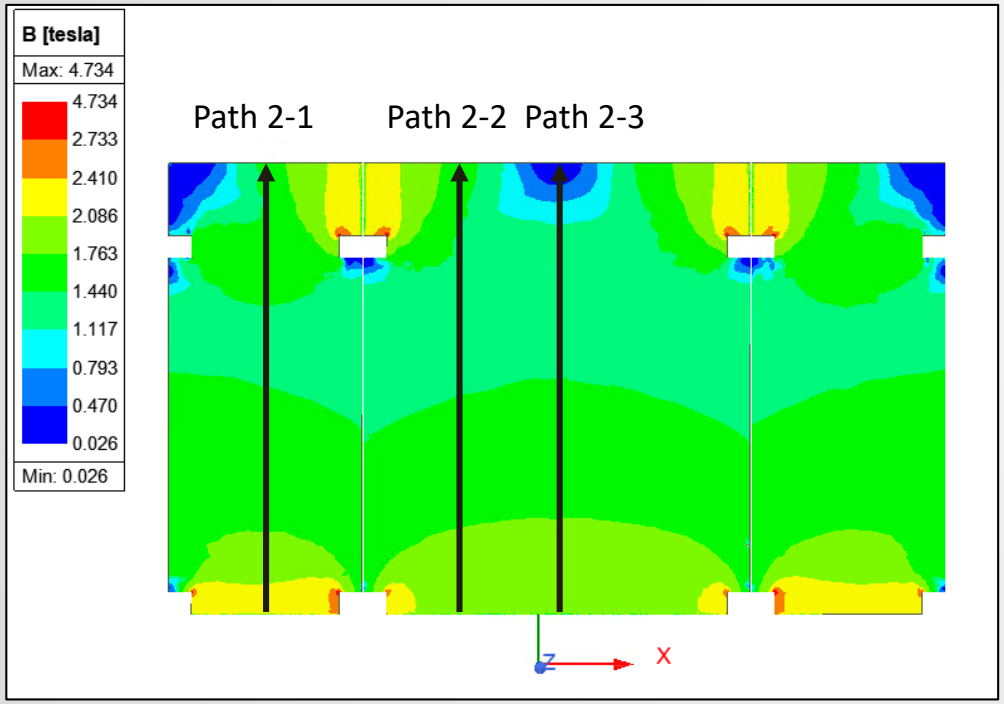
(OLD MODEL, 20TH 15MM THICK PLATE)

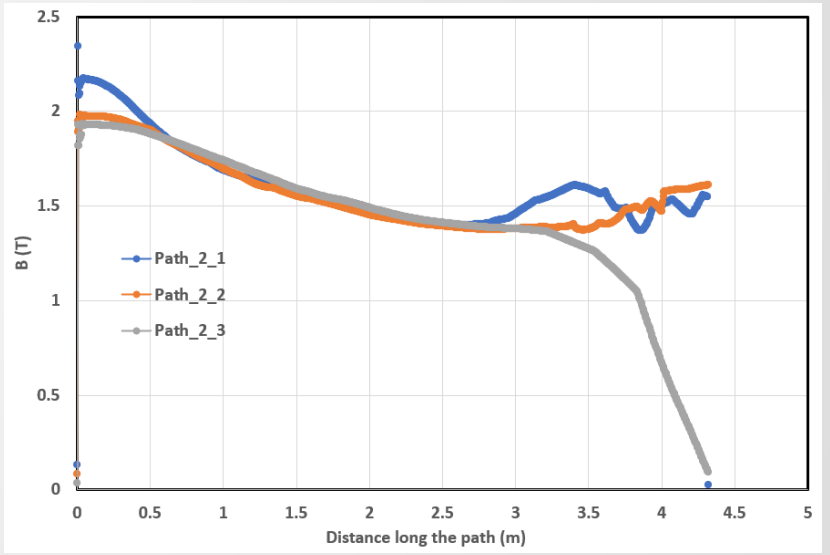




“B” ALONG PATHS

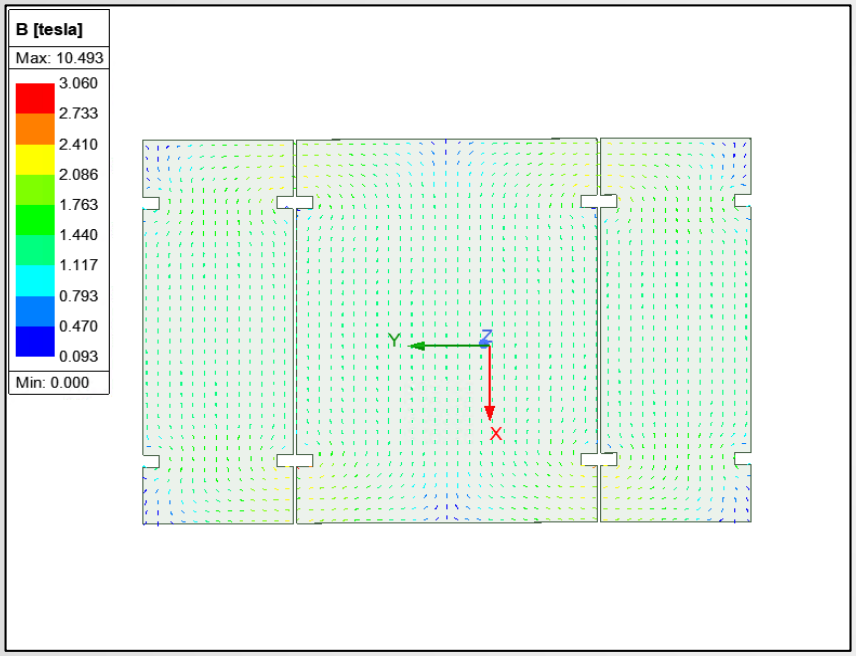
(NEW MODEL, 20TH 15MM THICK PLATE)

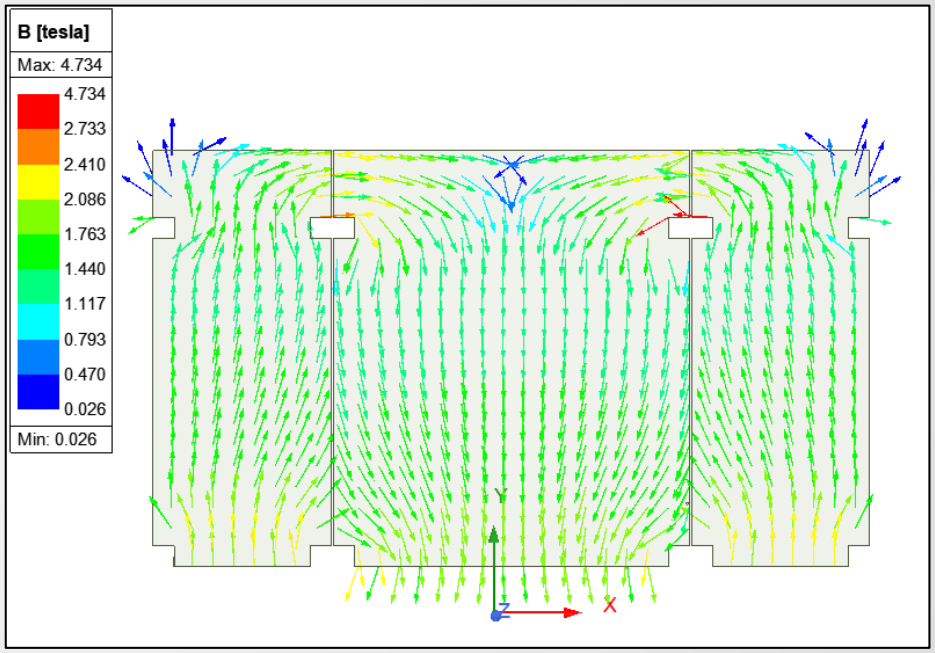




“B” distribution on the 20th 15mm thick plate

(Vector)





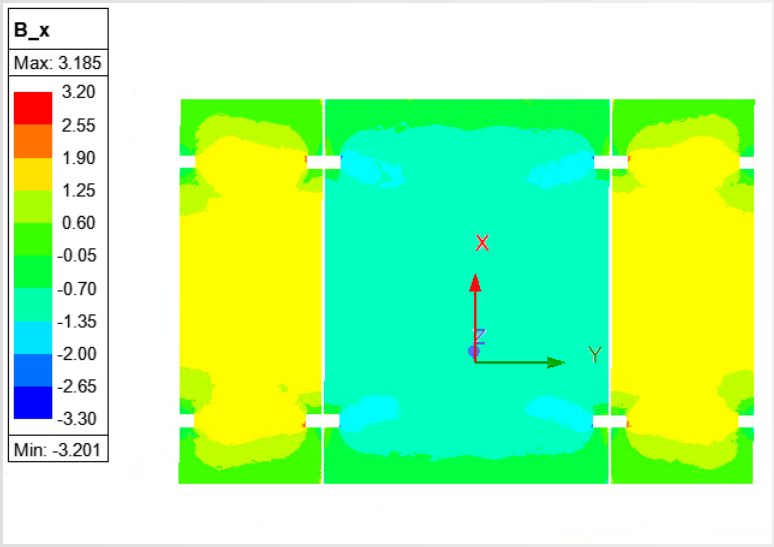
(a)

Old

(b)

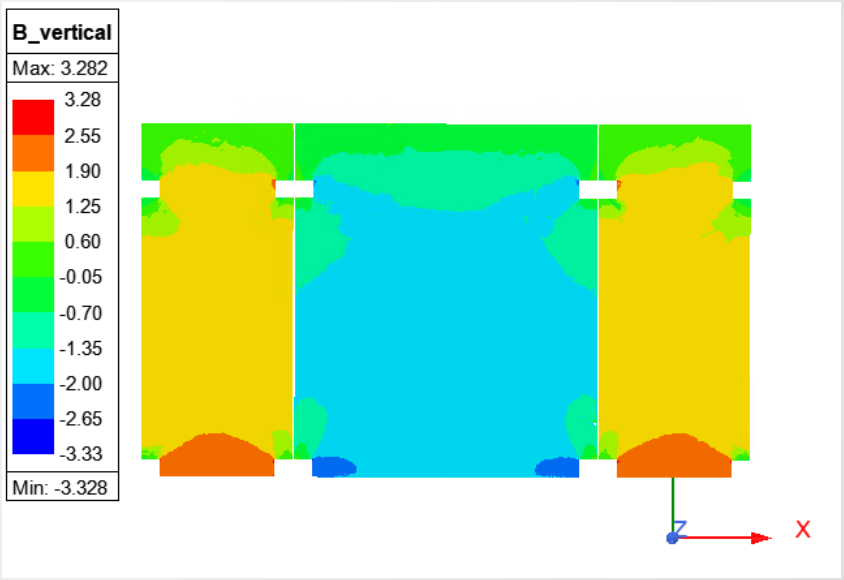
New

“B_vertical” distribution on the 20th 15mm thick plate



(a)

Old

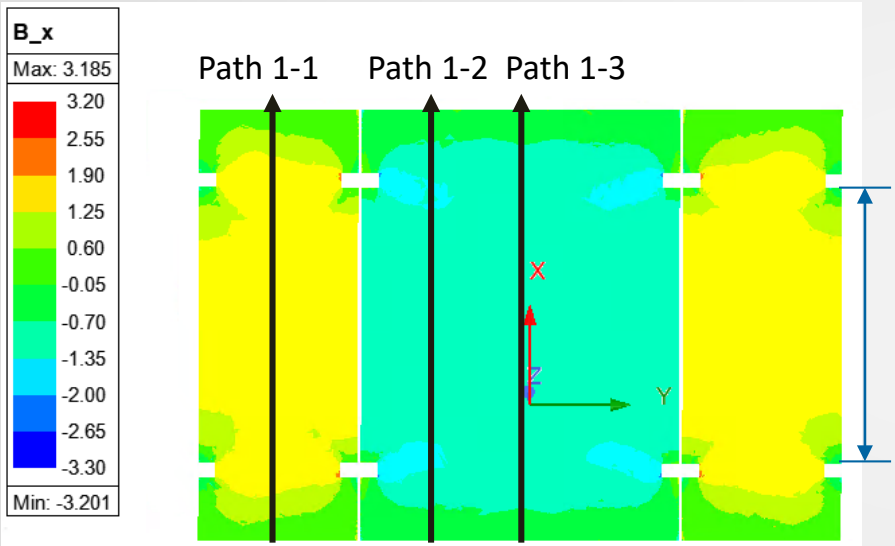


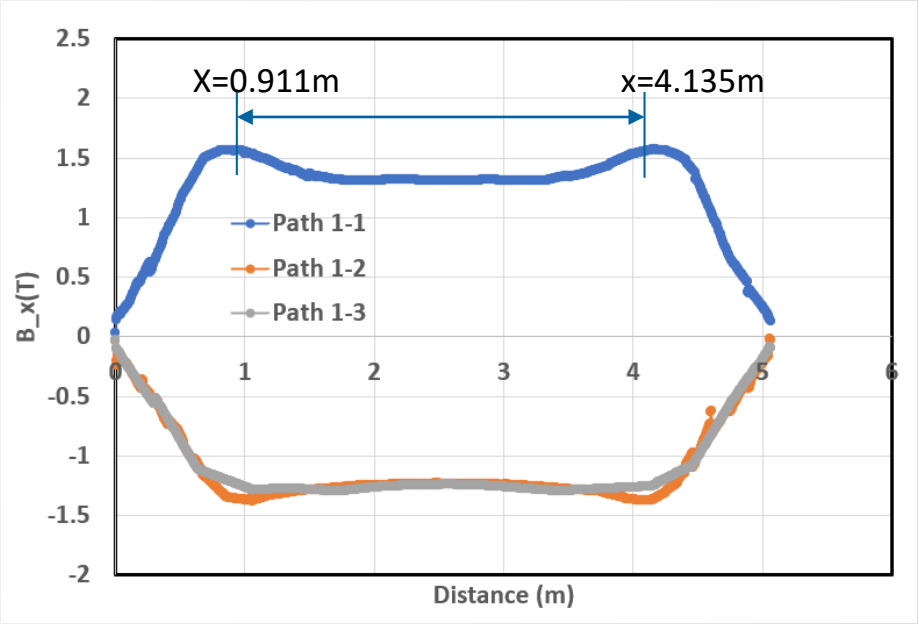
(b)

New

“B_VERTICAL” ALONG PATHS

(OLD MODEL, 20TH 15MM THICK PLATE)





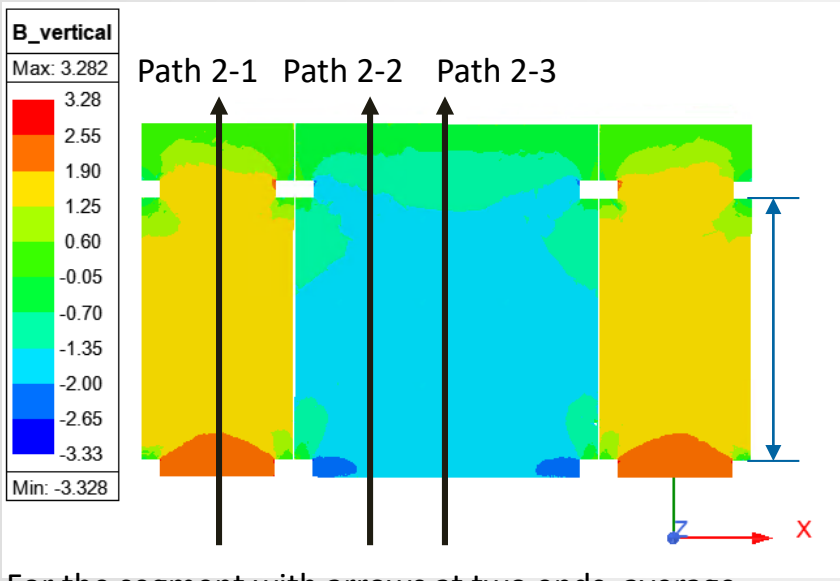
For the segment with arrows at two ends, average and standard deviation (T):

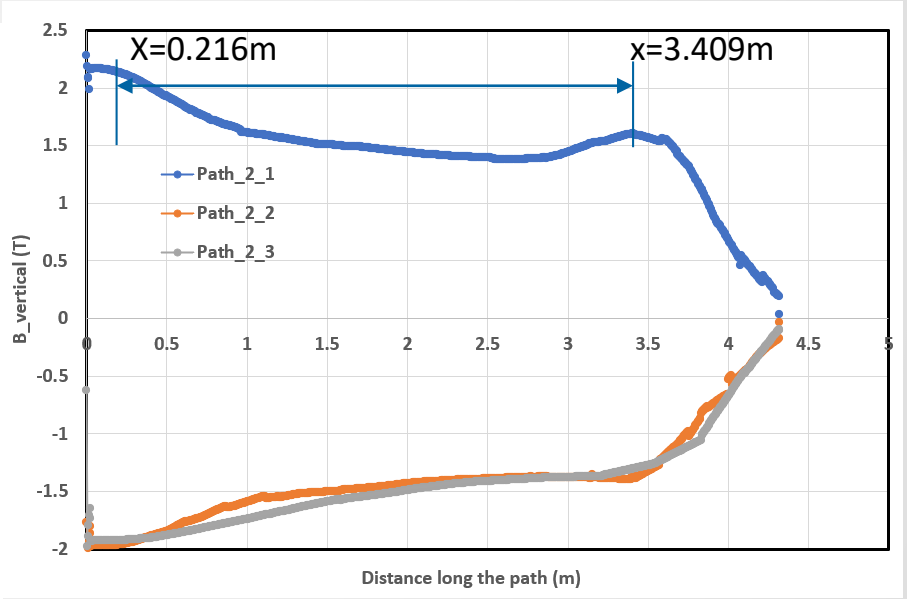
$$\frac{\sum_{i=1}^{i=n} x_i}{n} \qquad \sqrt{\frac{\sum_{i=1}^{i=n}(x_i - \bar{x})^2}{n-1}}$$

	Path 1-1	Path 1-2	Path 1-3
Ave.	1.3702	-1.2792	-1.2691
St. Dev.	0.0806	0.0446	0.0174

“B_VERTICAL” ALONG PATHS

(NEW MODEL, 20TH 15MM THICK PLATE)





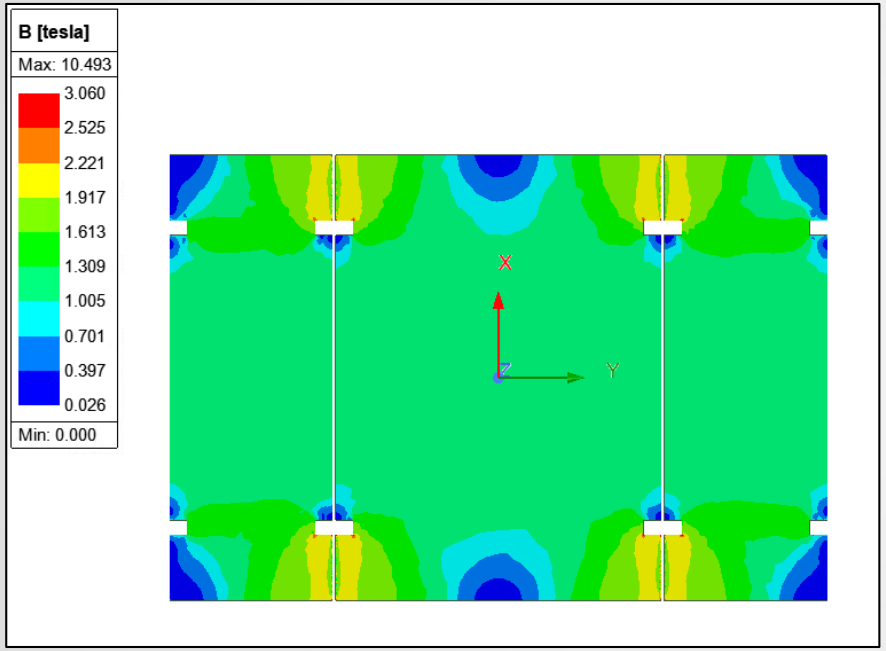
For the segment with arrows at two ends, average and standard deviation (T):

$$\frac{\sum_{i=1}^{i=n} x_i}{n} \qquad \sqrt{\frac{\sum_{i=1}^{i=n}(x_i - \bar{x})^2}{n-1}}$$

	Path 2-1	Path 2-2	Path 2-3
Ave.	1.5674	-1.5206	-1.5722
St.Dev.	0.1928	0.1663	0.1872

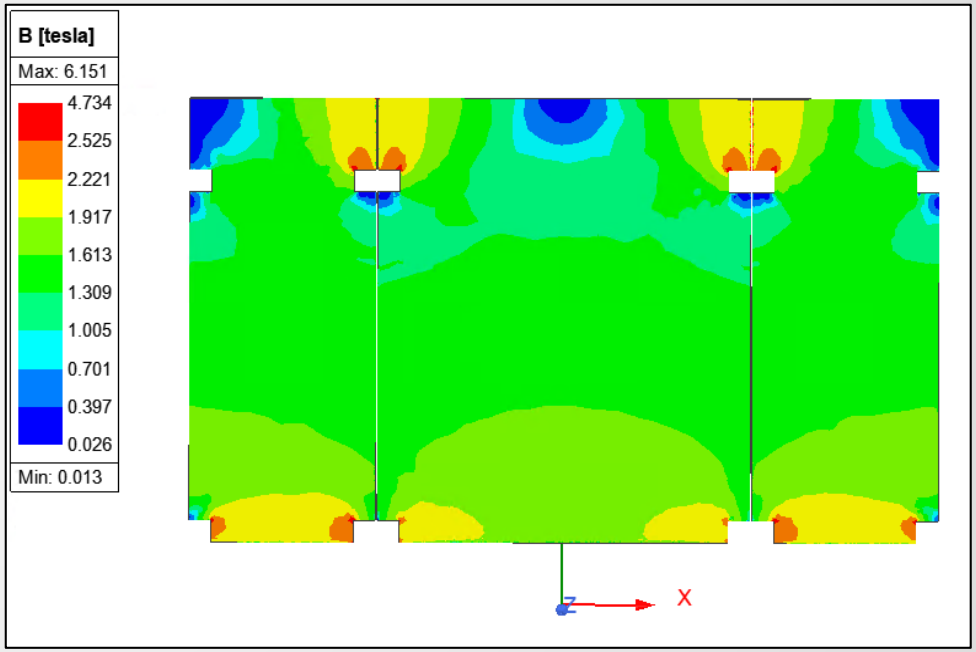
“B” distribution on the 70th 40mm thick plate

(Magnitude)



(a)

Old

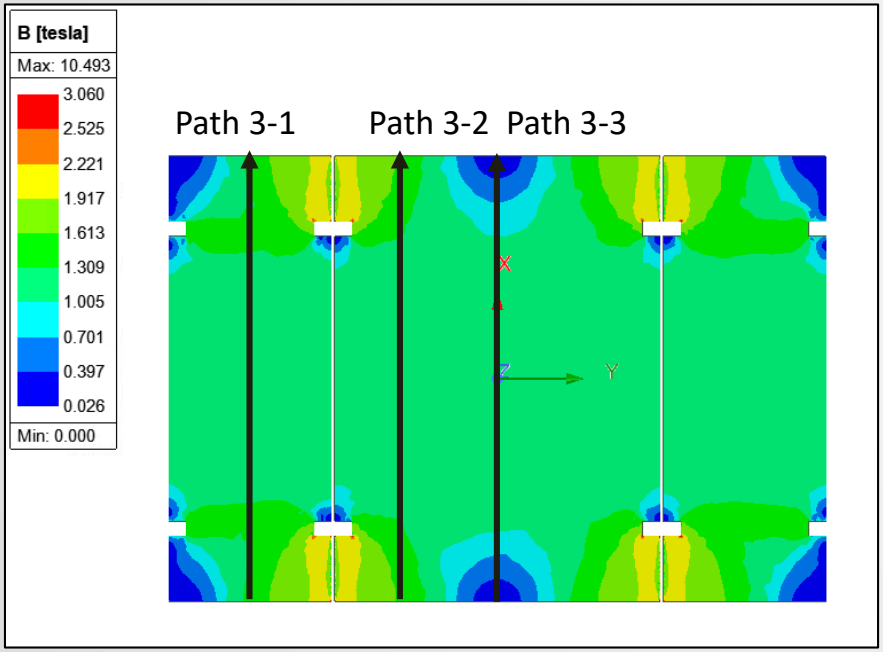


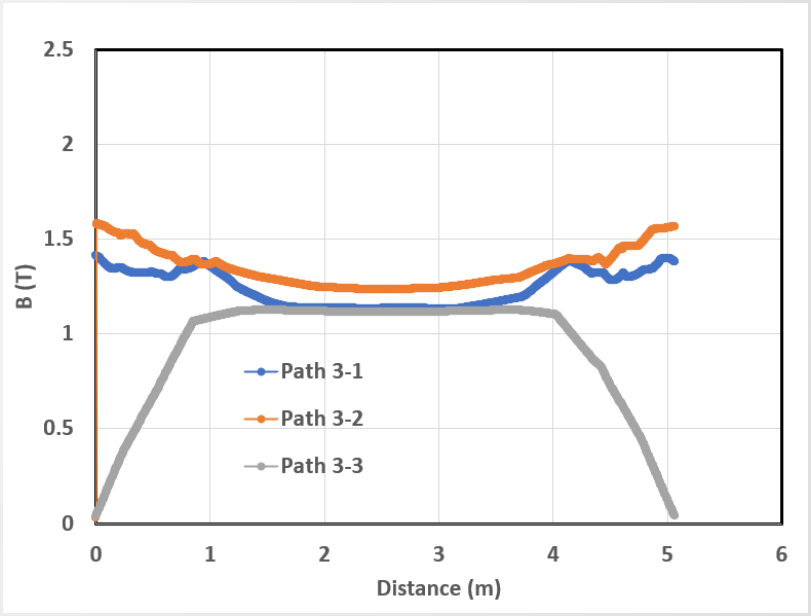
(b)

New

“B” ALONG PATHS

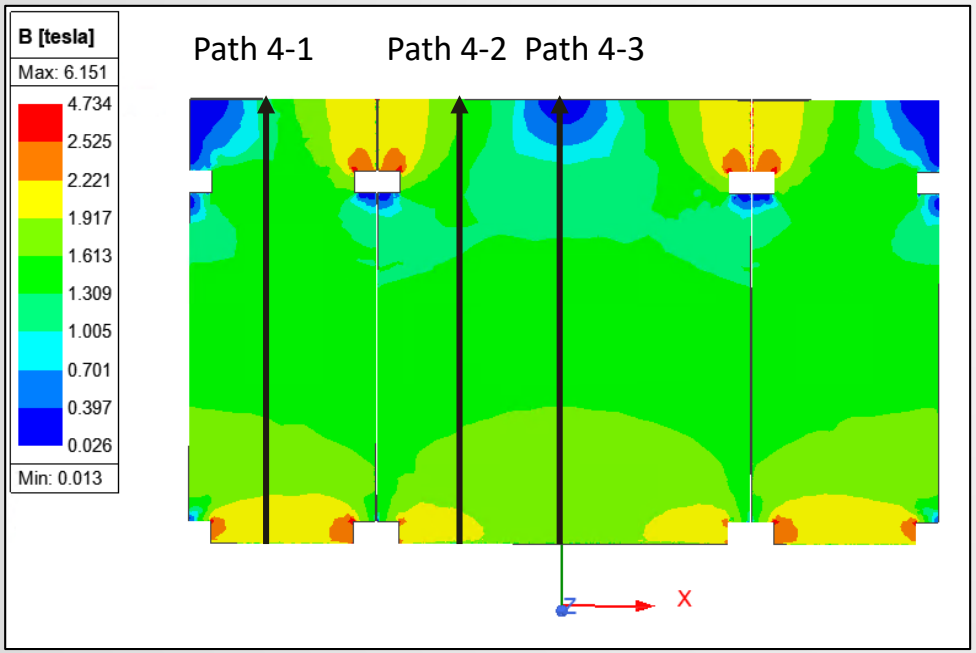
(OLD MODEL, 70TH 40MM THICK PLATE)

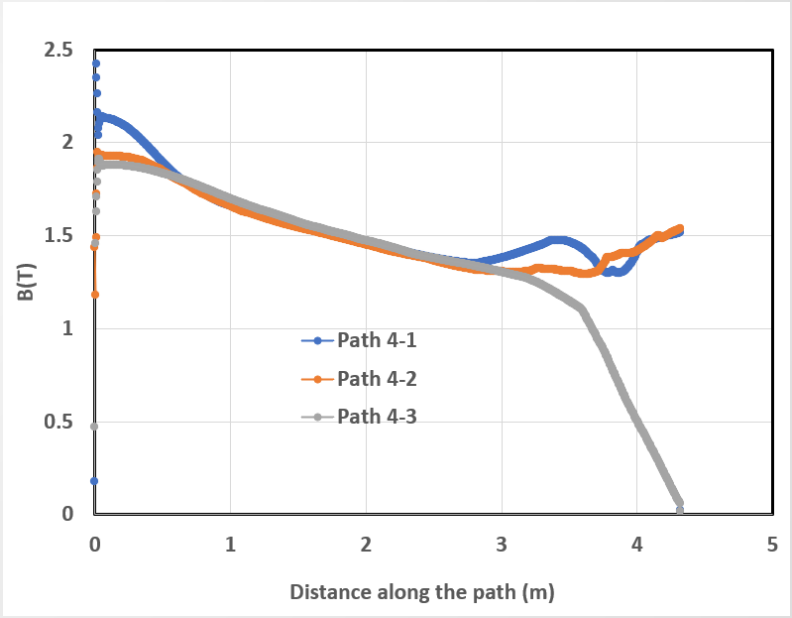




“B” ALONG PATHS

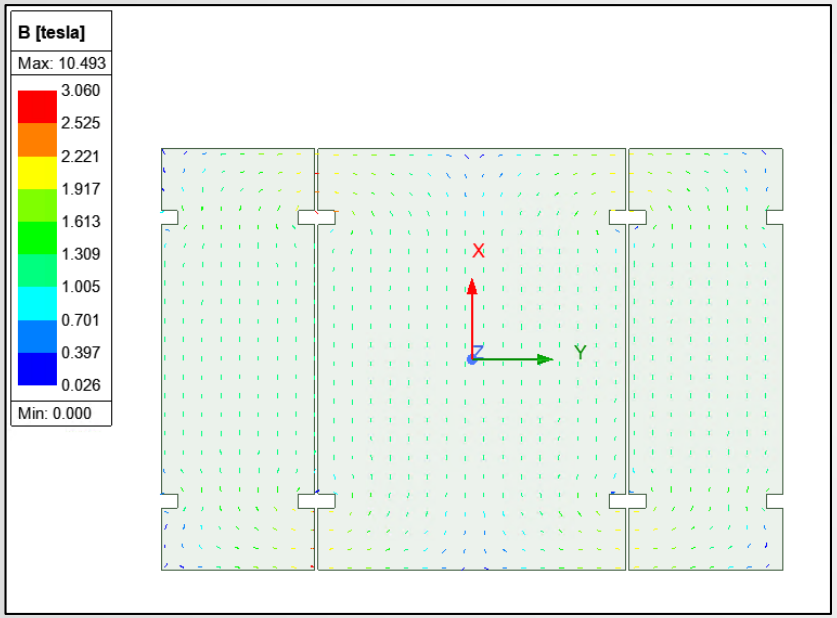
(NEW MODEL, 70TH 40MM THICK PLATE)





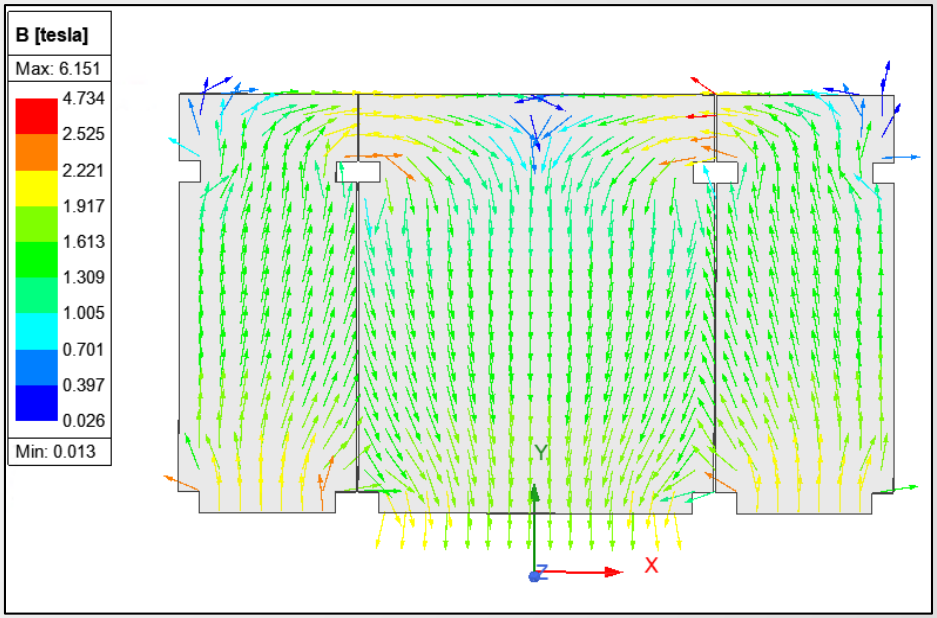
“B” distribution on the 70th 40mm thick plate

(Vector)



(a)

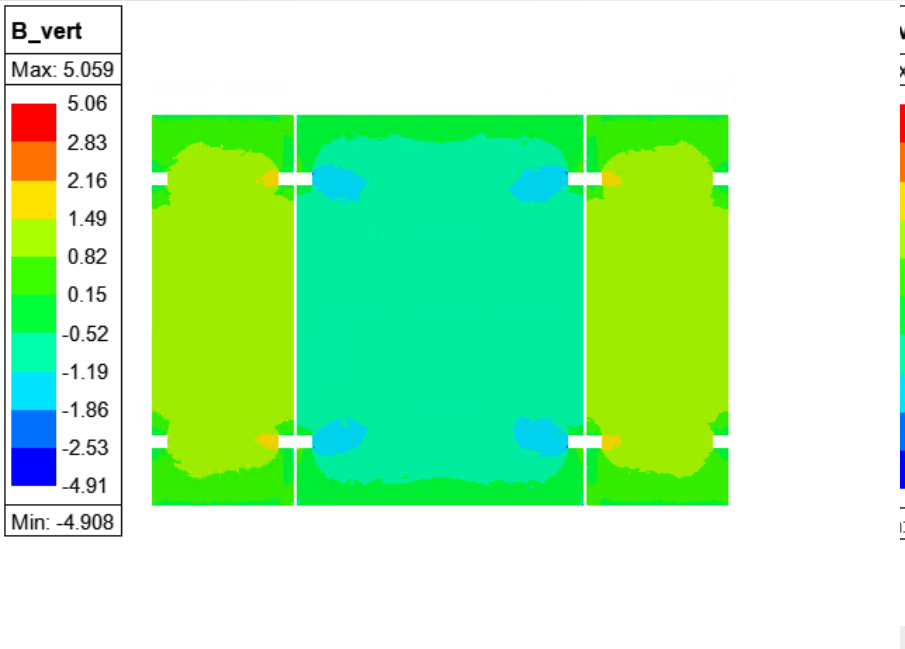
Old



(b)

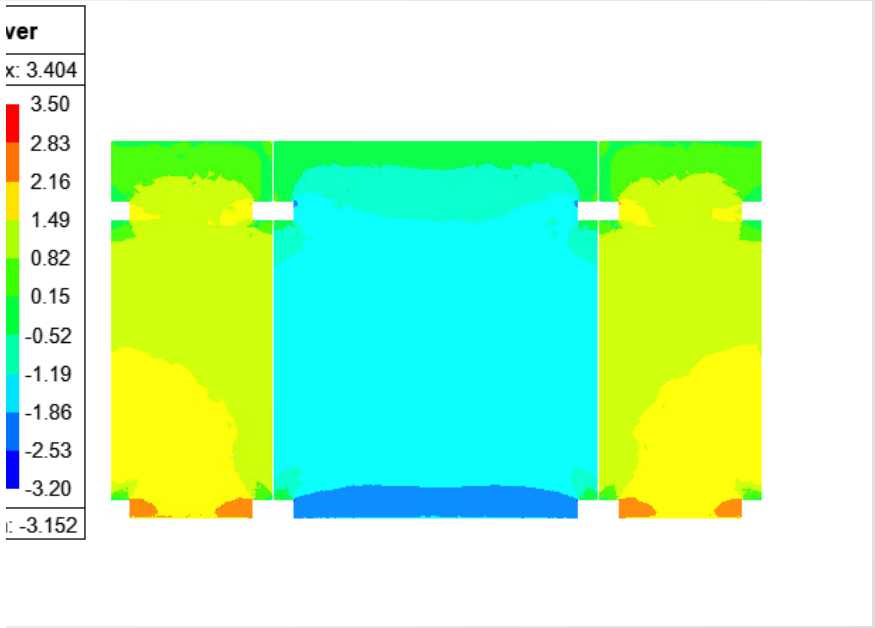
New

“B_vertical” distribution on the 70th 40mm thick plate



(a)

Old

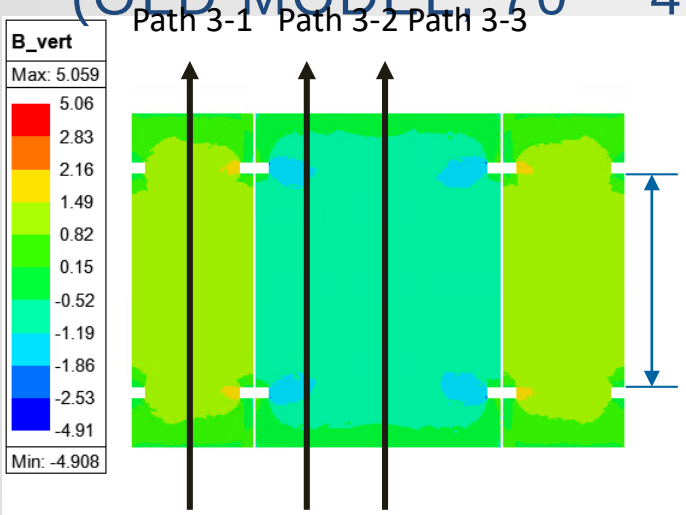


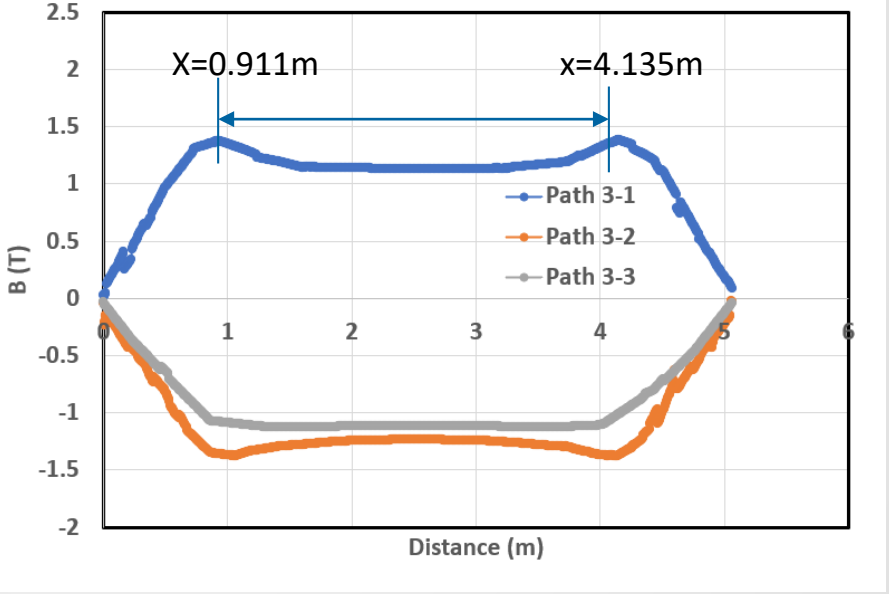
(b)

New

"B_VERTICAL" ALONG PATHS

(OLD MODEL, 70TH 40





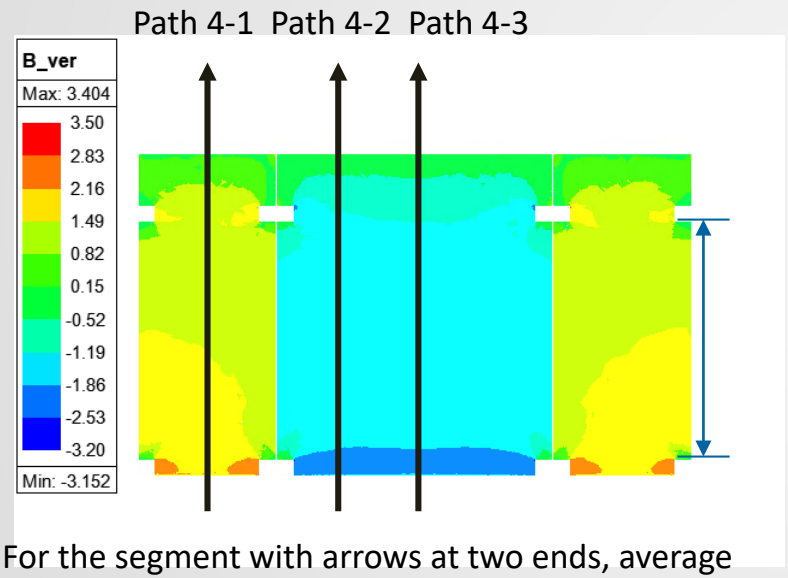
For the segment with arrows at two ends, average and standard deviation (T):

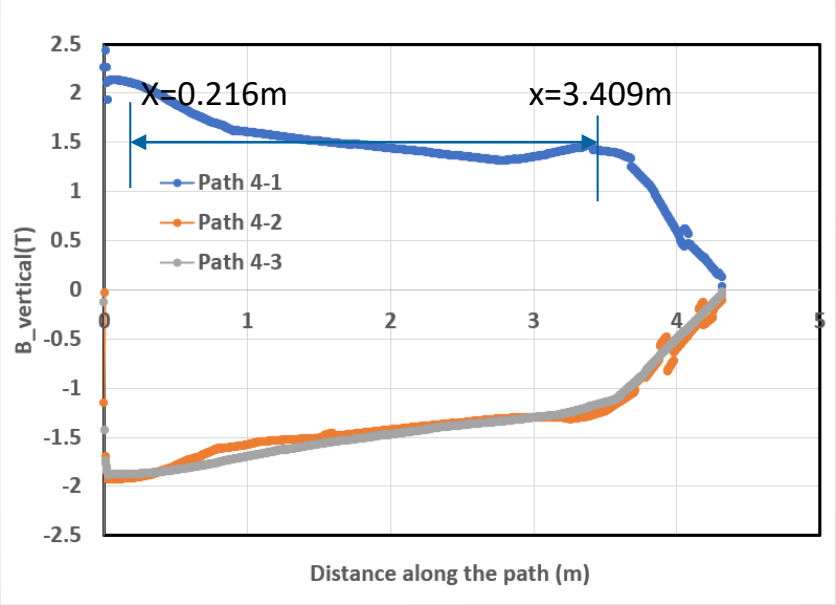
$$\frac{\sum_{i=1}^{i=n} x_i}{n} \qquad \sqrt{\frac{\sum_{i=1}^{i=n}(x_i - \bar{x})^2}{n-1}}$$

	Path 3-1	Path 3-2	Path 3-3
Ave.	1.1828	-1.1281	-1.1155
St. Dev.	0.0695	0.0202	0.0122

“B_VERTICAL” ALONG PATHS

(NEW MODEL, 70TH 40MM THICK PLATE)

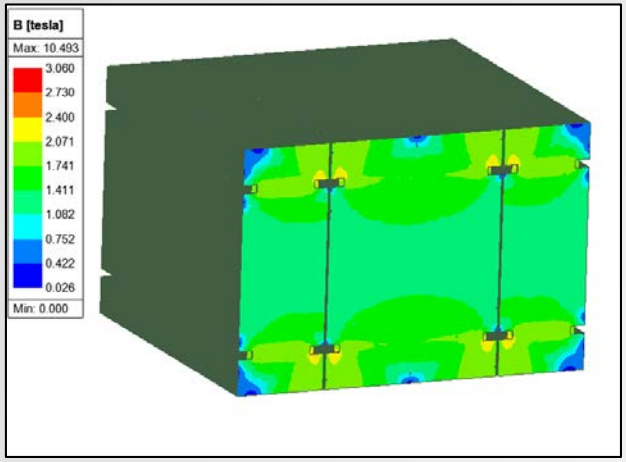




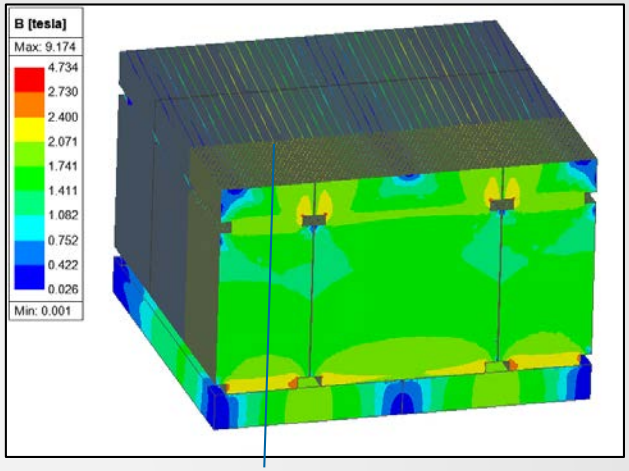
For the segment with arrows at two ends, average and standard deviation (T):

$$\frac{\sum_{i=1}^{i=n} x_i}{n} \qquad \sqrt{\frac{\sum_{i=1}^{i=n}(x_i - \bar{x})^2}{n-1}}$$

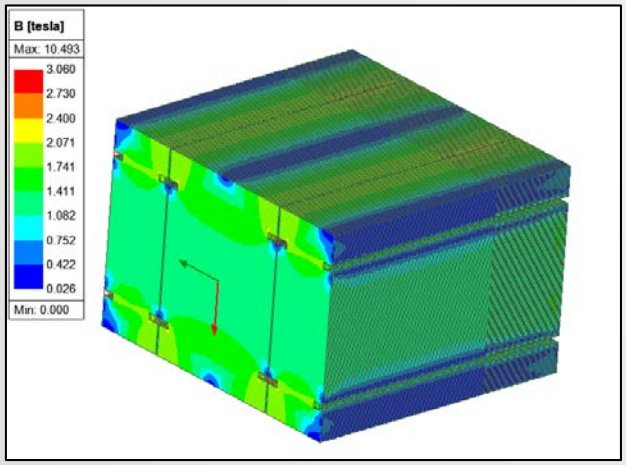
	Path 4-1	Path 4-2	Path 4-3
Ave. (T)	1.5296	-1.4863	-1.5305
Stan. Dev.	0.1963	0.1704	0.1954



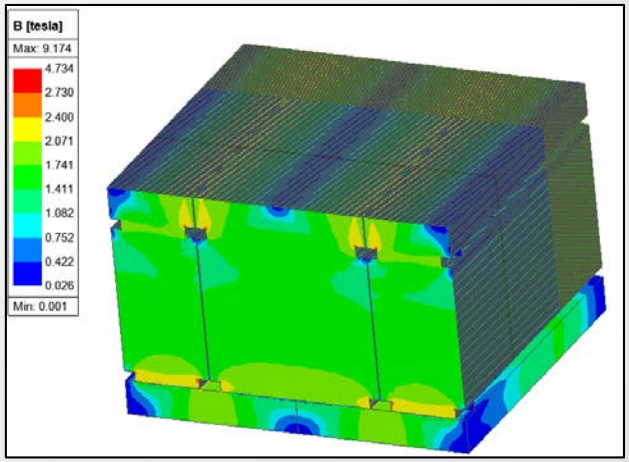
Front-old



Front-new

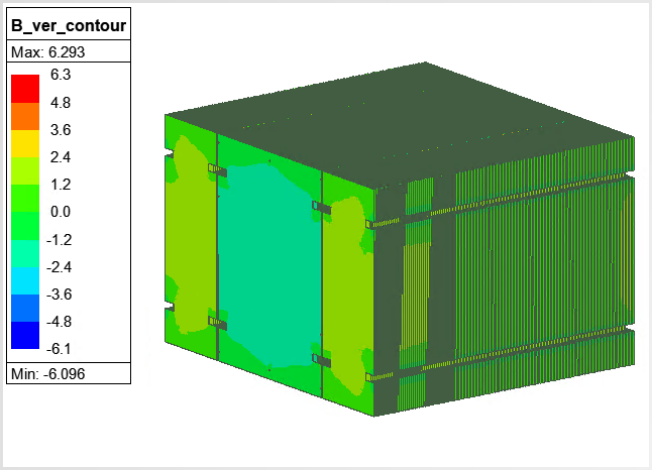


Back-old

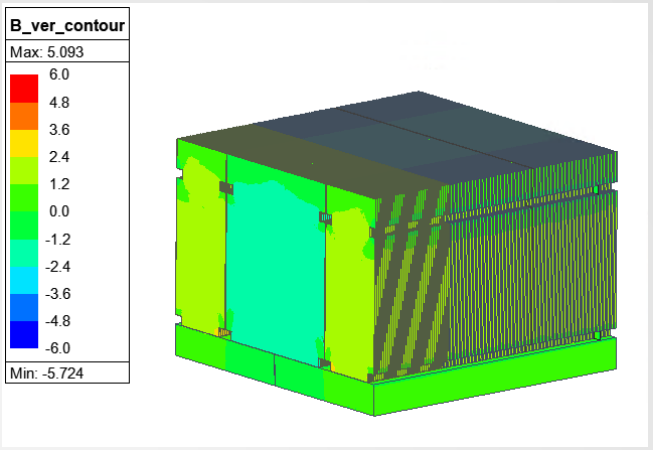


Back-new

B

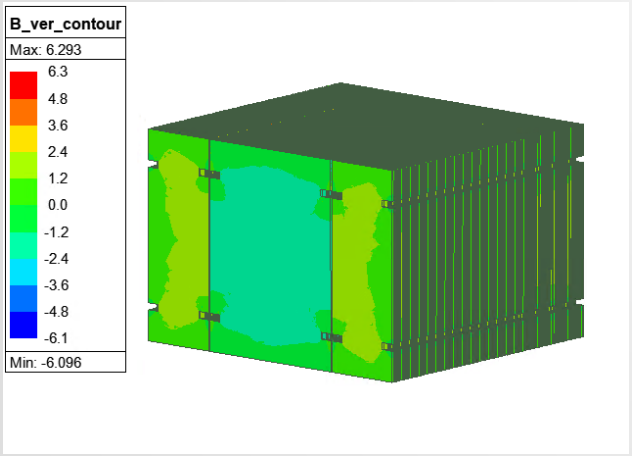


Front-old

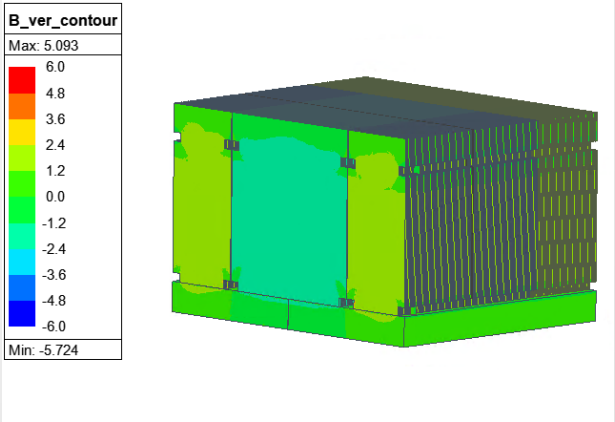


Front-new

B_ver

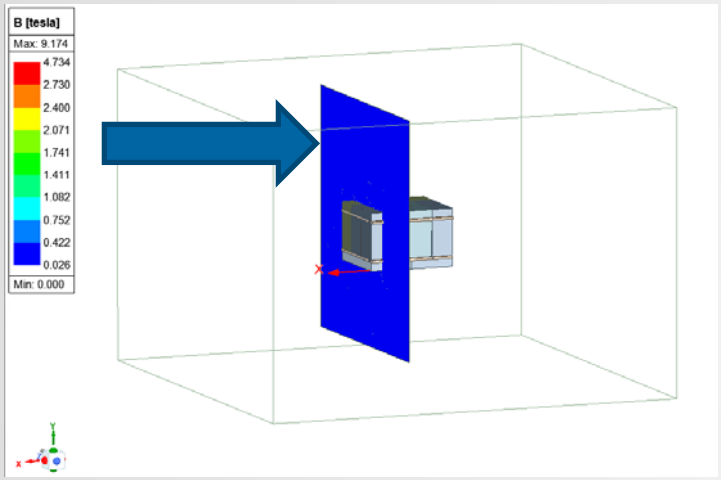


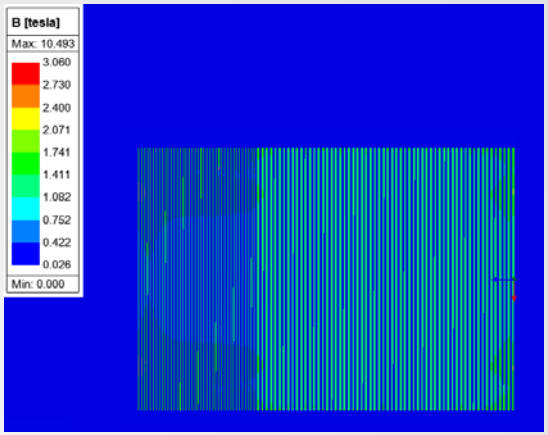
Back-old



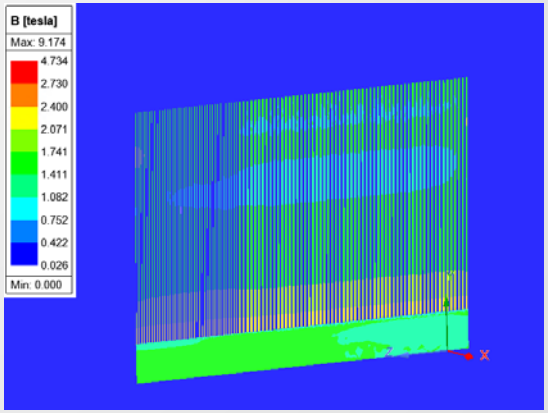
Back-new

Cross section view of “B”



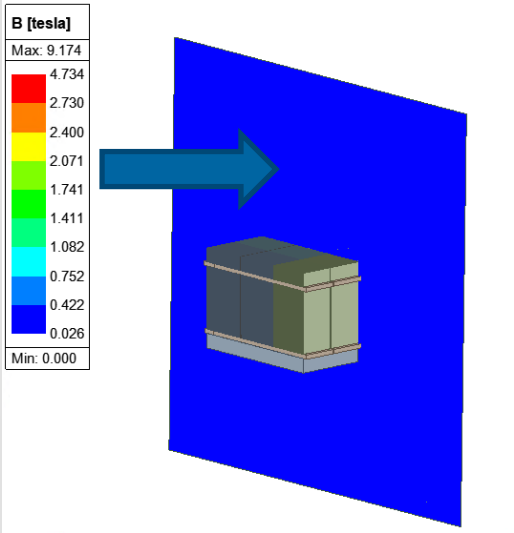


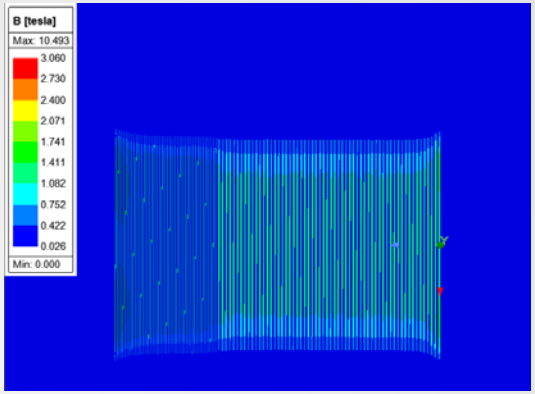
Old model



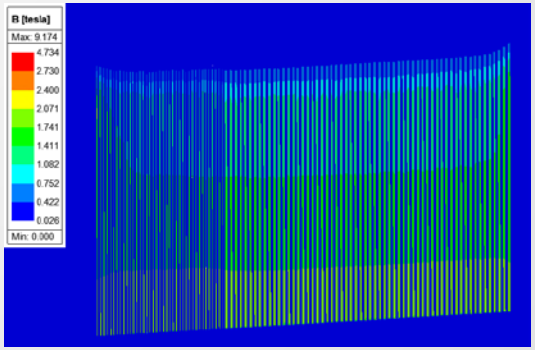
New model

Cross section view of “B”



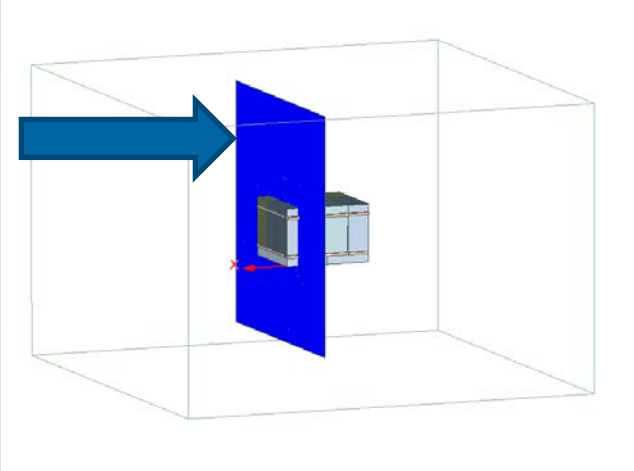


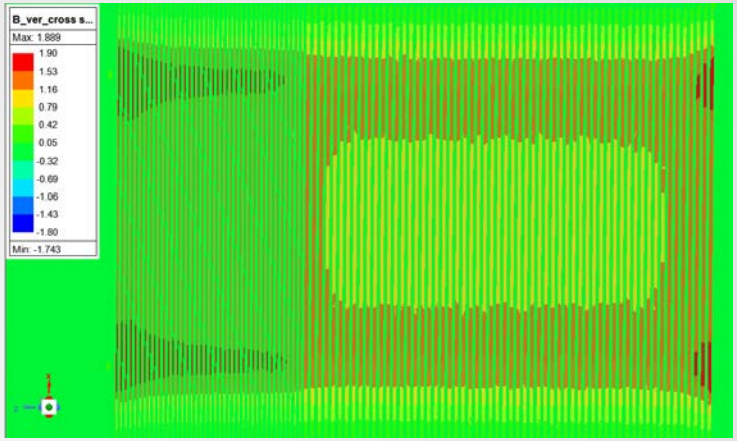
Old model



New model

Cross section view of “B_vertical”

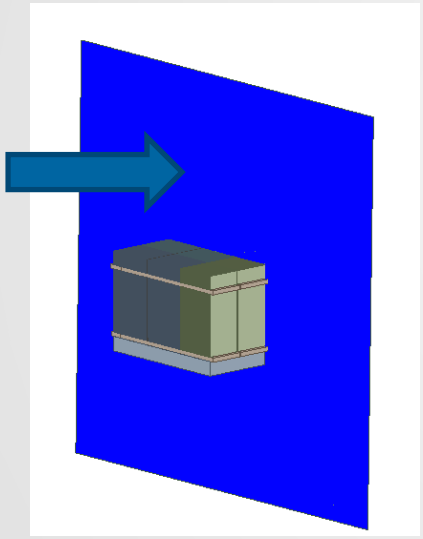


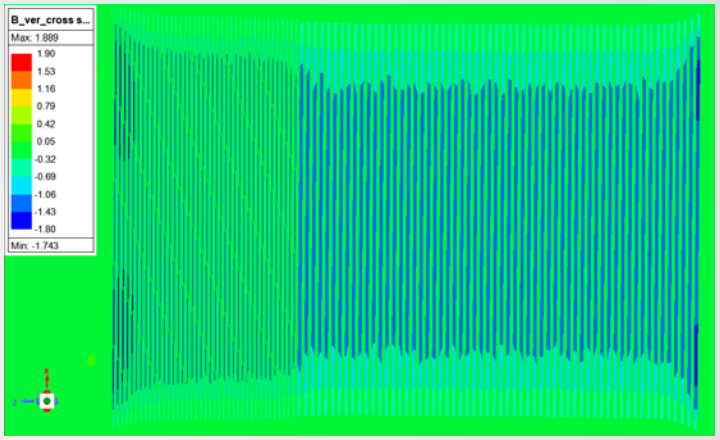


Old model

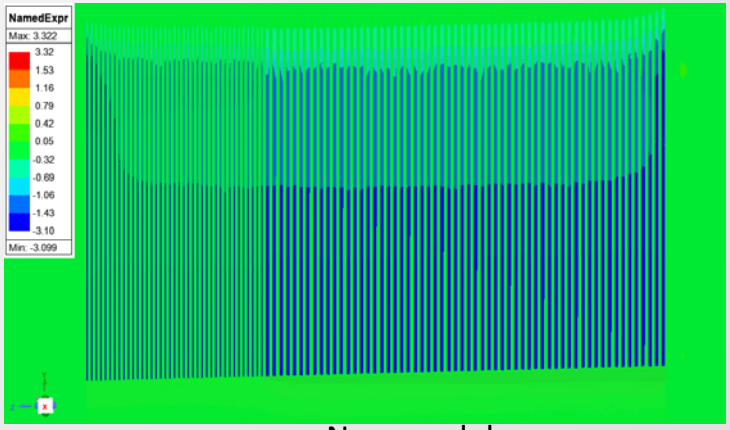
New model

Cross section view of “B_vertical”



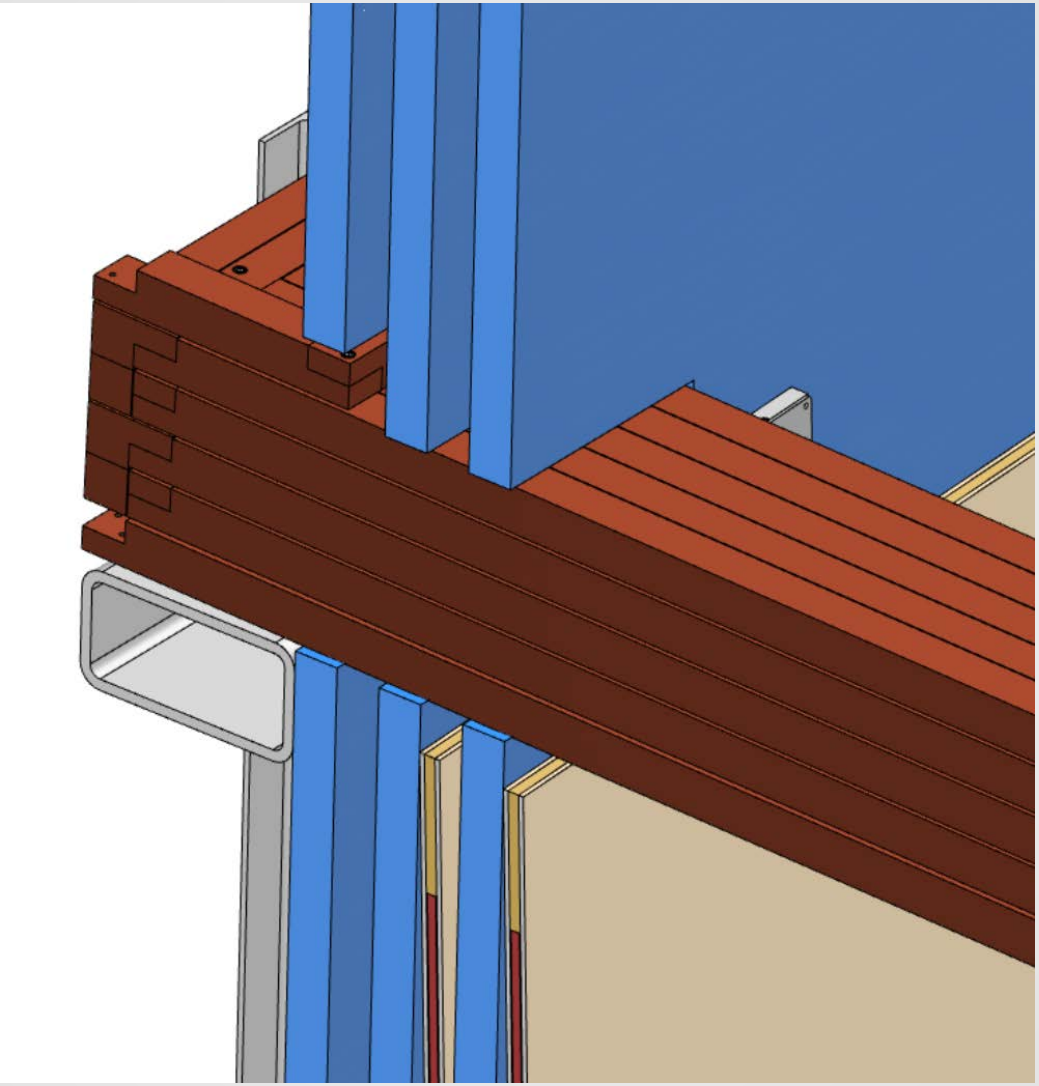


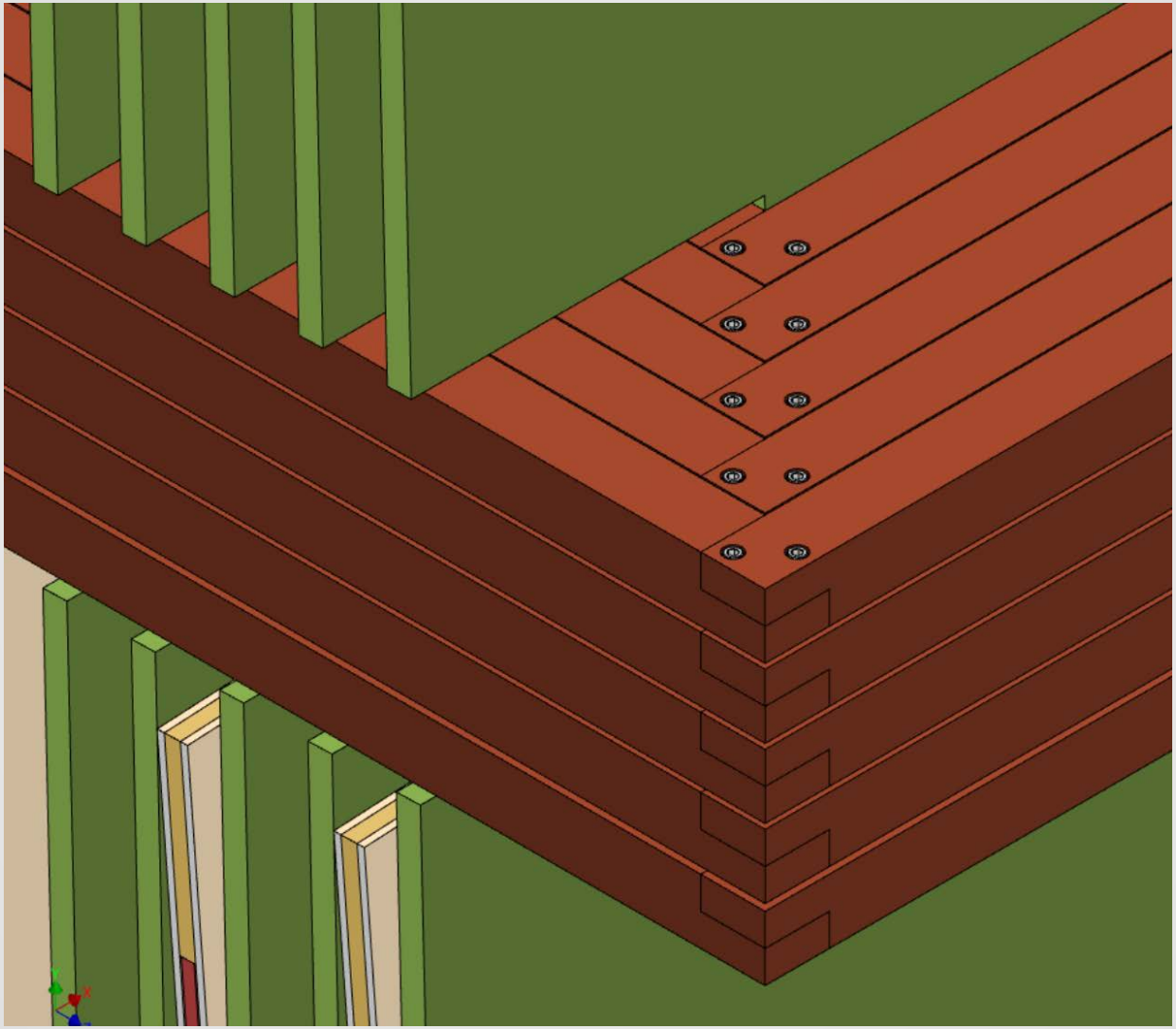
Old model



New model

BACKUP SLIDES





Insulation details

- Conductors will wrapped in insulation.
- G-10 will be used to insulate at connections.