Cross-talk Control between Q1BpF & Q1eF

(understanding & implementation of the novel solution)

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BROOKHAVEN NATIONAL LABORATORY

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Office of Science
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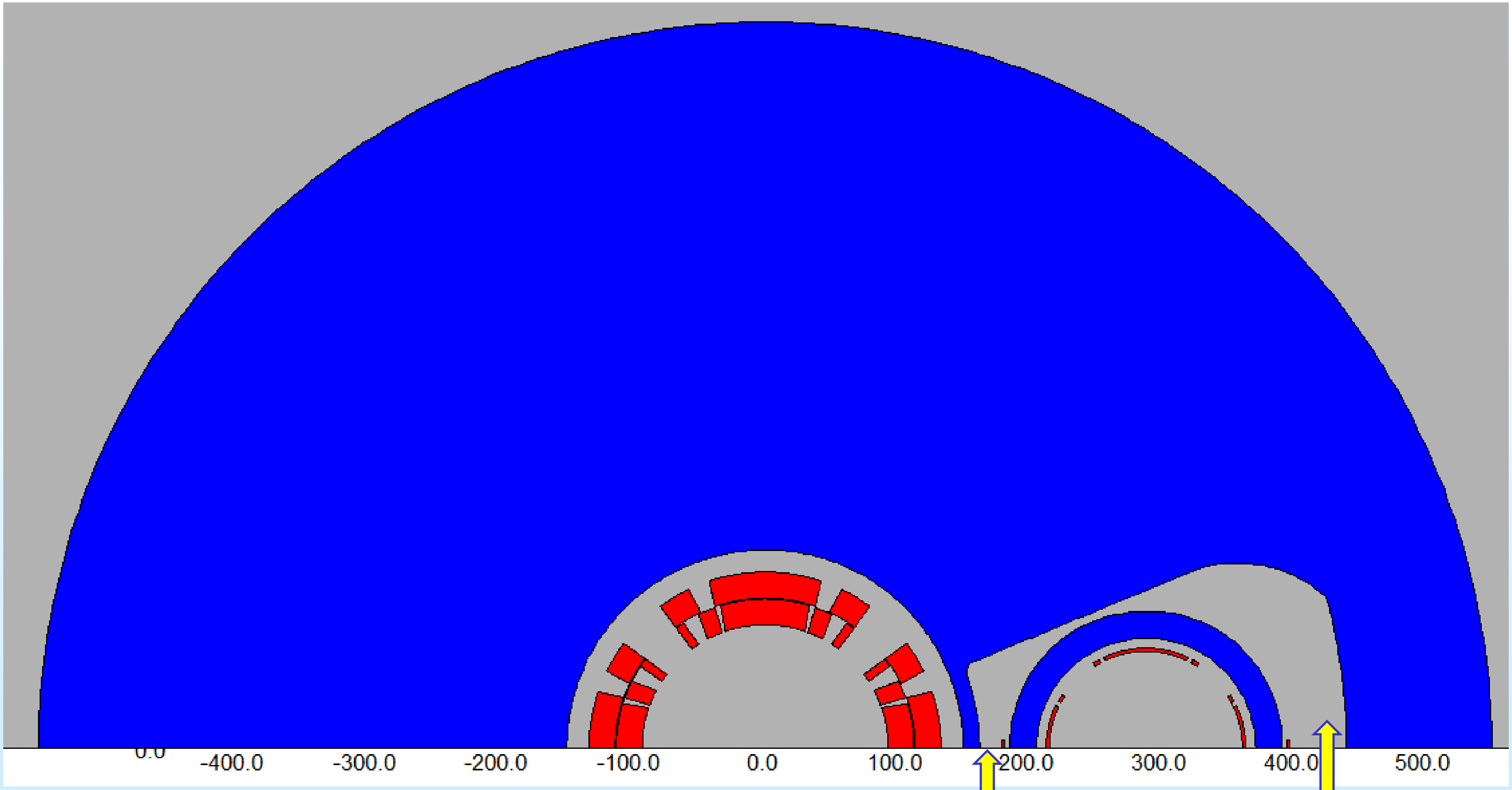
Overview

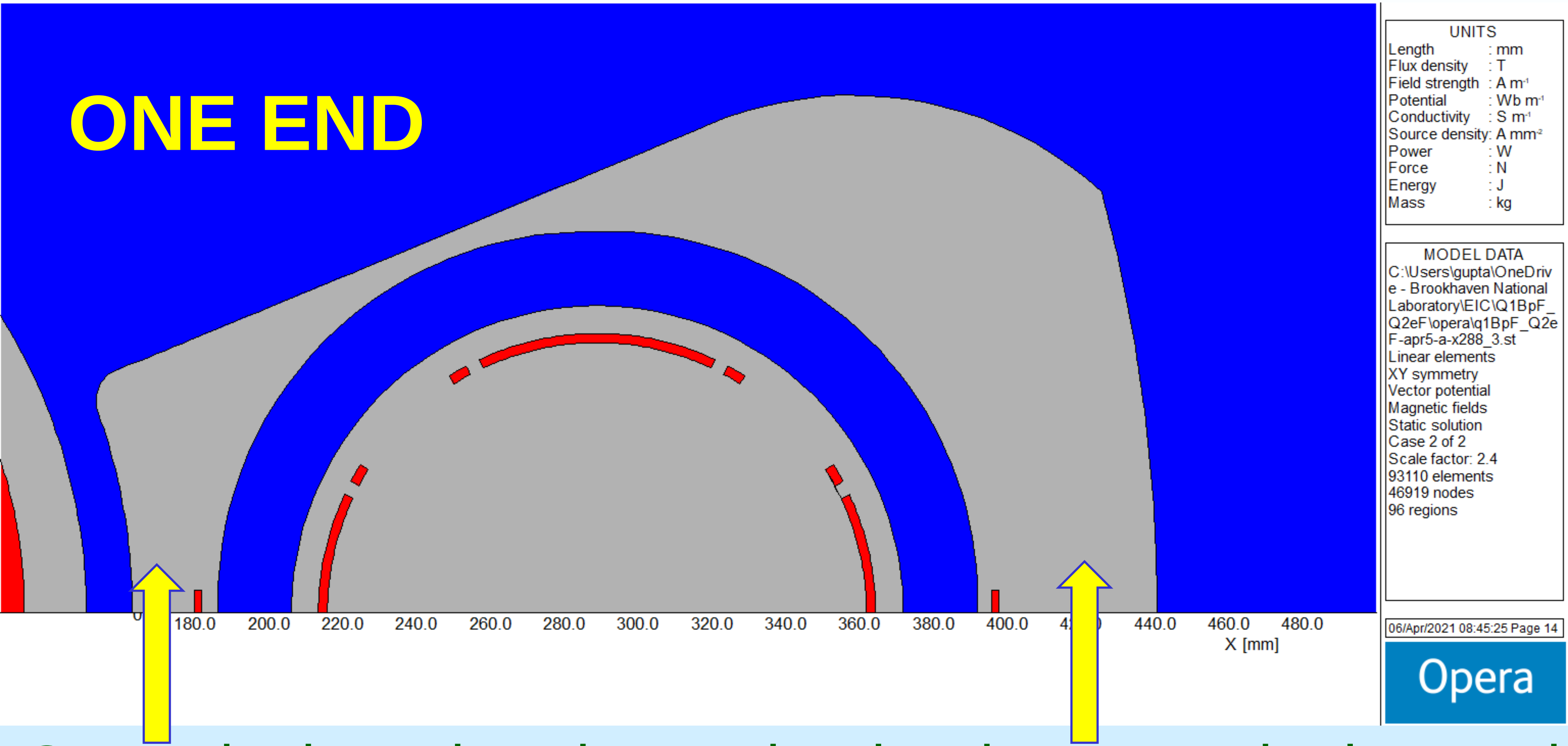
- This presentation explains the unique and novel strategy for reducing cross-talk between Q1BpF and Q1eF
- It tries to magnetically decouple the two quadrupoles by creating conditions so that magnetic shielding can work despite a high leakage field by reducing yoke saturation
- It uses correctors (a sort of) not to shape the field inside the quadrupoles directly but to keep field in the iron at the crucial places low enough so that it is able to shield
- The first defense against the cross talk is an air barrier and then the additional coils, as and if needed
- This presentation explains the approach and implementation so that it can be properly used

The Basic Model (1)



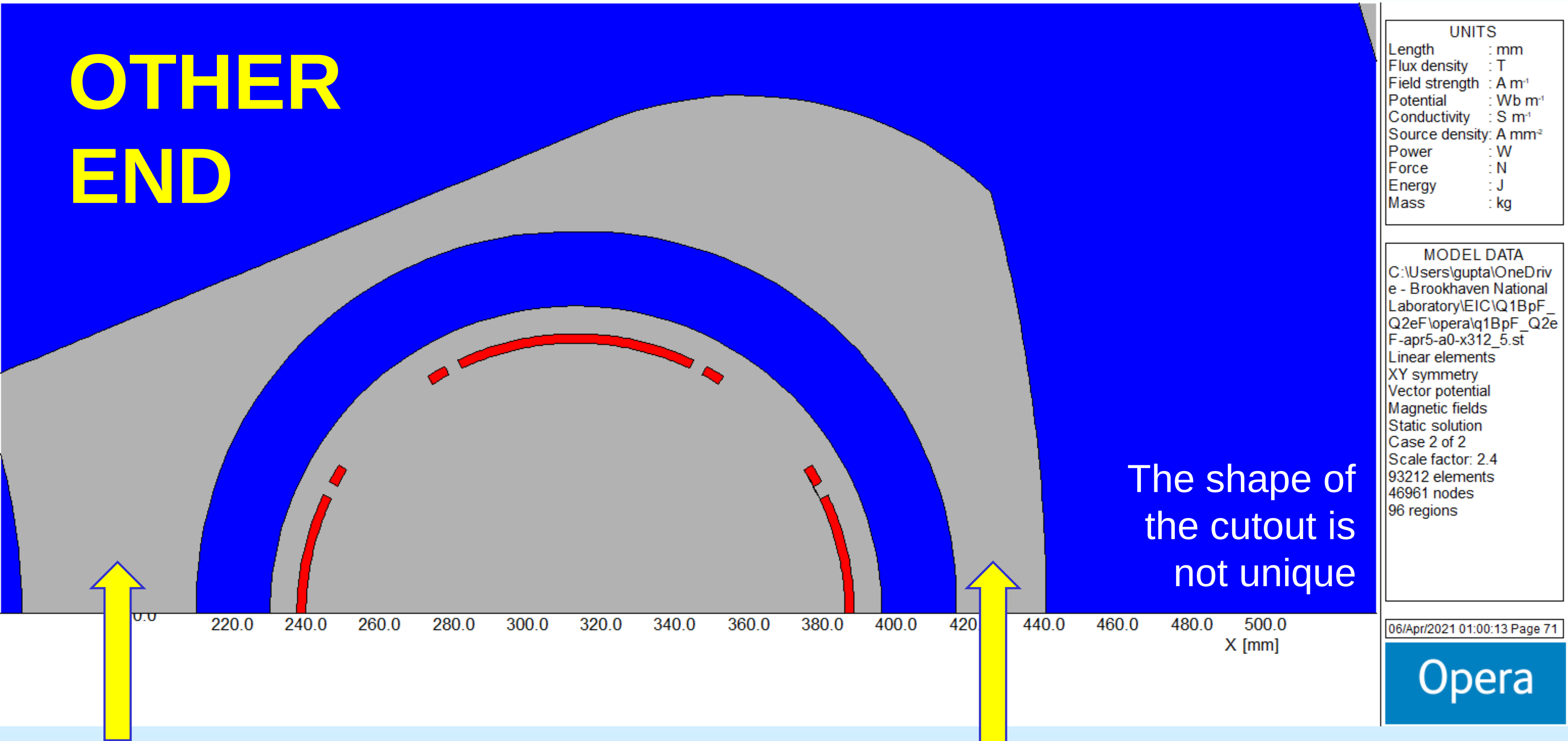
Cutout in the yoke where other hardware can be inserted

The Basic Model (2)



Cutout in the yoke where other hardware can be inserted (with rounded corners for the cutout)

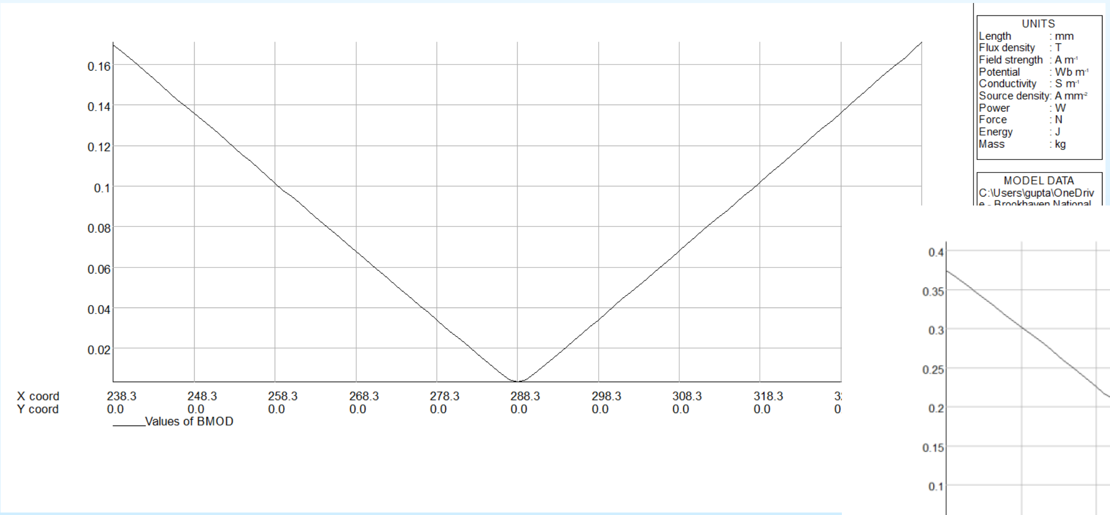
The Basic Model (3)



Cutout in the yoke where other hardware can be inserted (with rounded corners for the cutout)

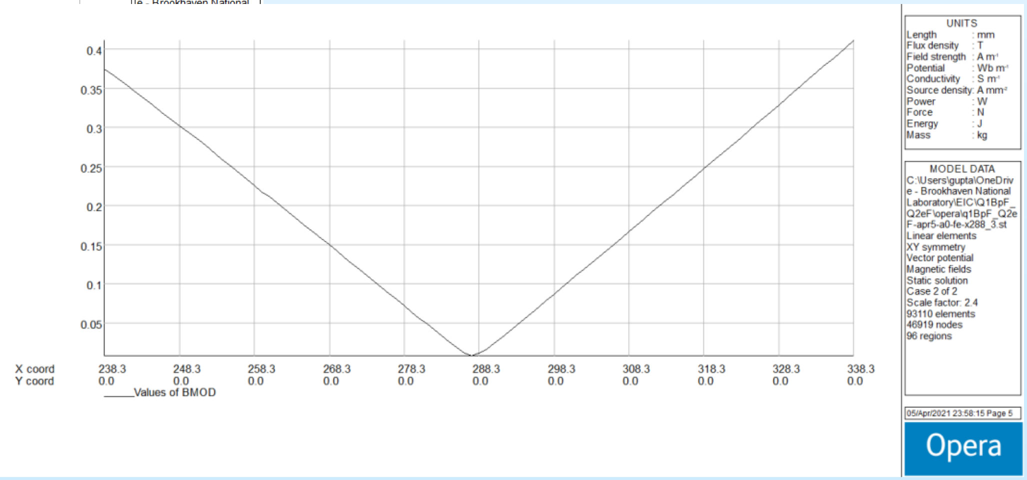
The Issue

- ➢ **Close proximity (leakage field) create cross-talk between Q1BpF and Q1eF and distort the field quality at high level of excitation**
- ➢ **It can be seen most prominently by looking at the magnitude of the field on the x-axis of Q1eF**



(NOT symmetric at the design field)

(symmetric @40% of the design field)



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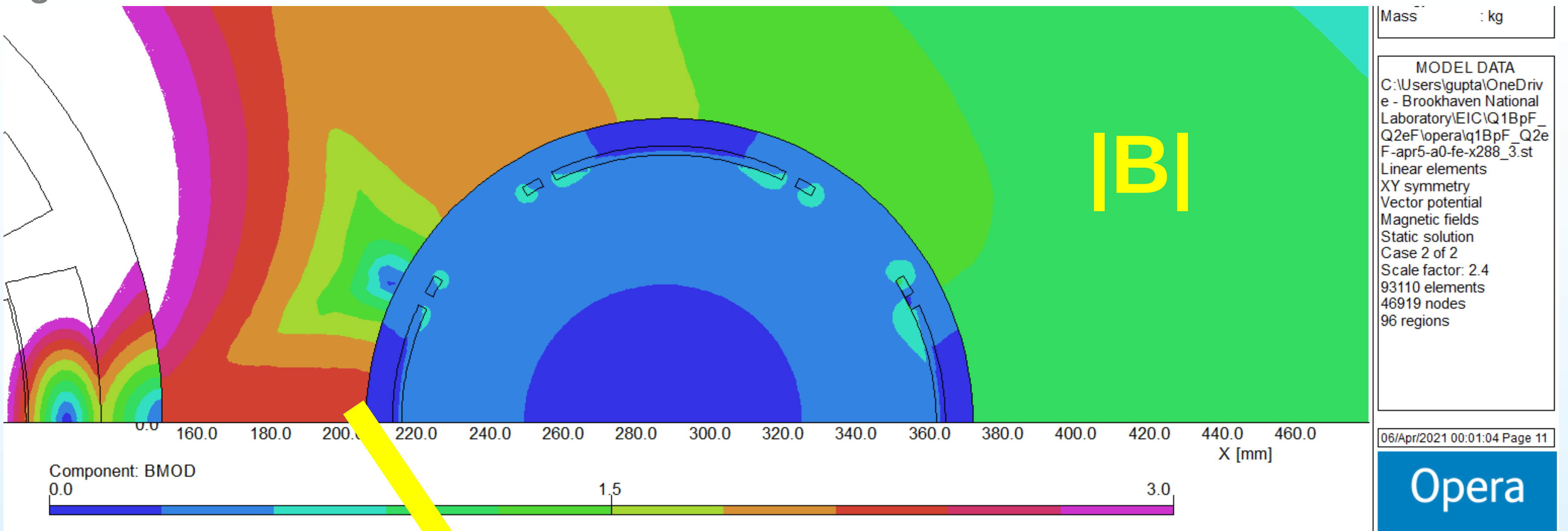
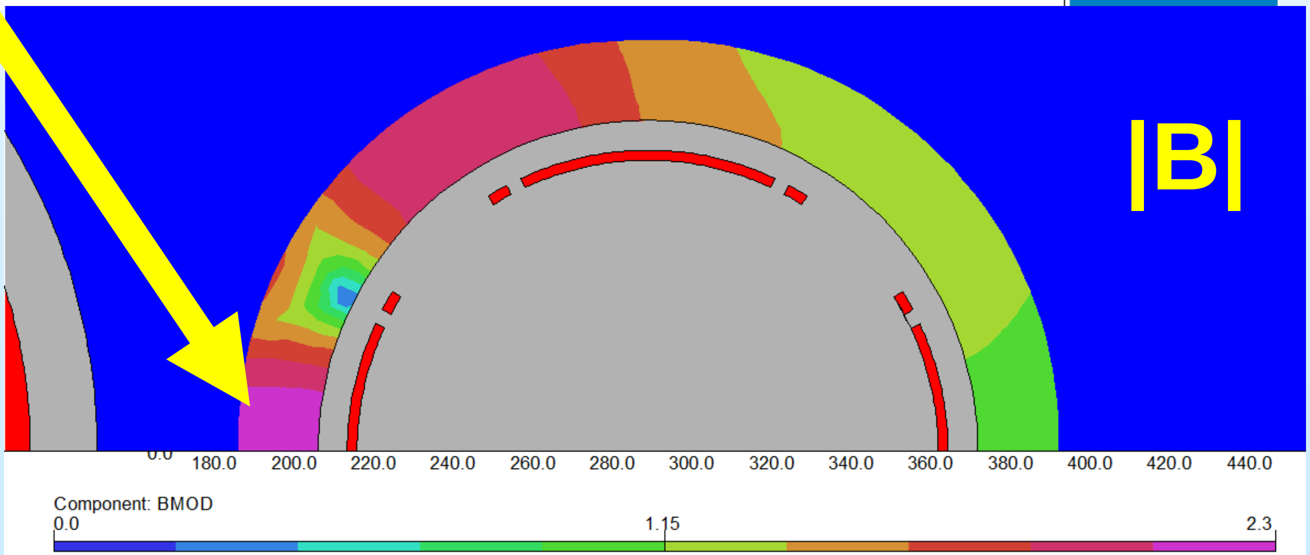
Magnitude of the Field in the Yoke

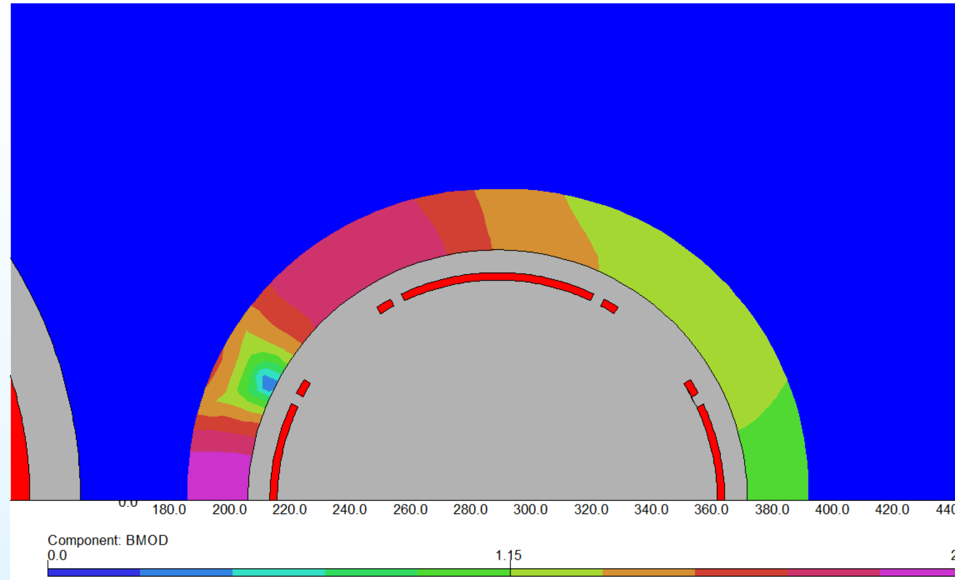


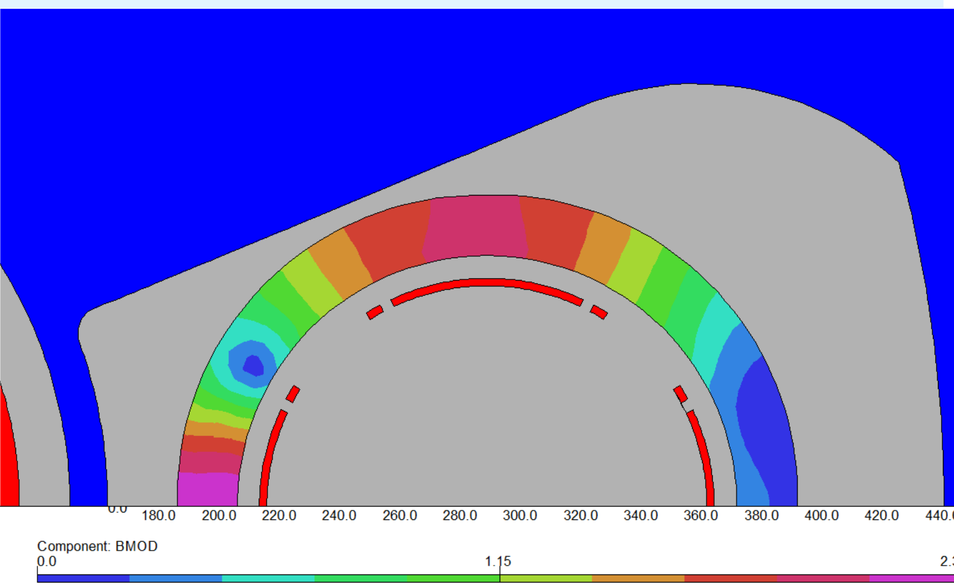
Large field (saturation) on the left side of the yoke of Q1eF

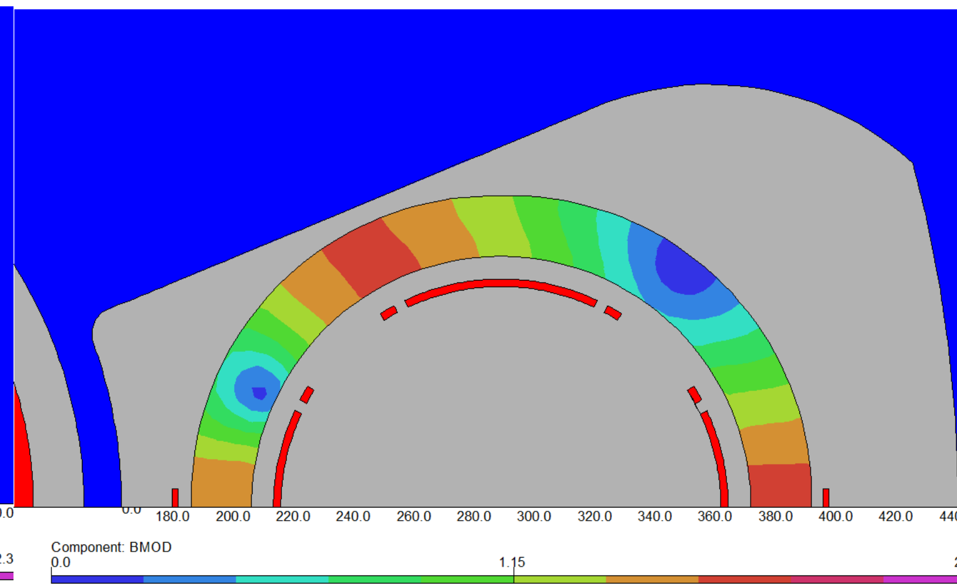


Development of the Design

1. Starting design: yoke between the two quad for maximum shielding
2. Cut out (to guide field lines away) and an iron ring around e-quad
3. Special corrector to reduce field in the iron ring (see reduction from ~2.3 Tesla max to ~1.6 Tesla. Yoke shielding works much better now

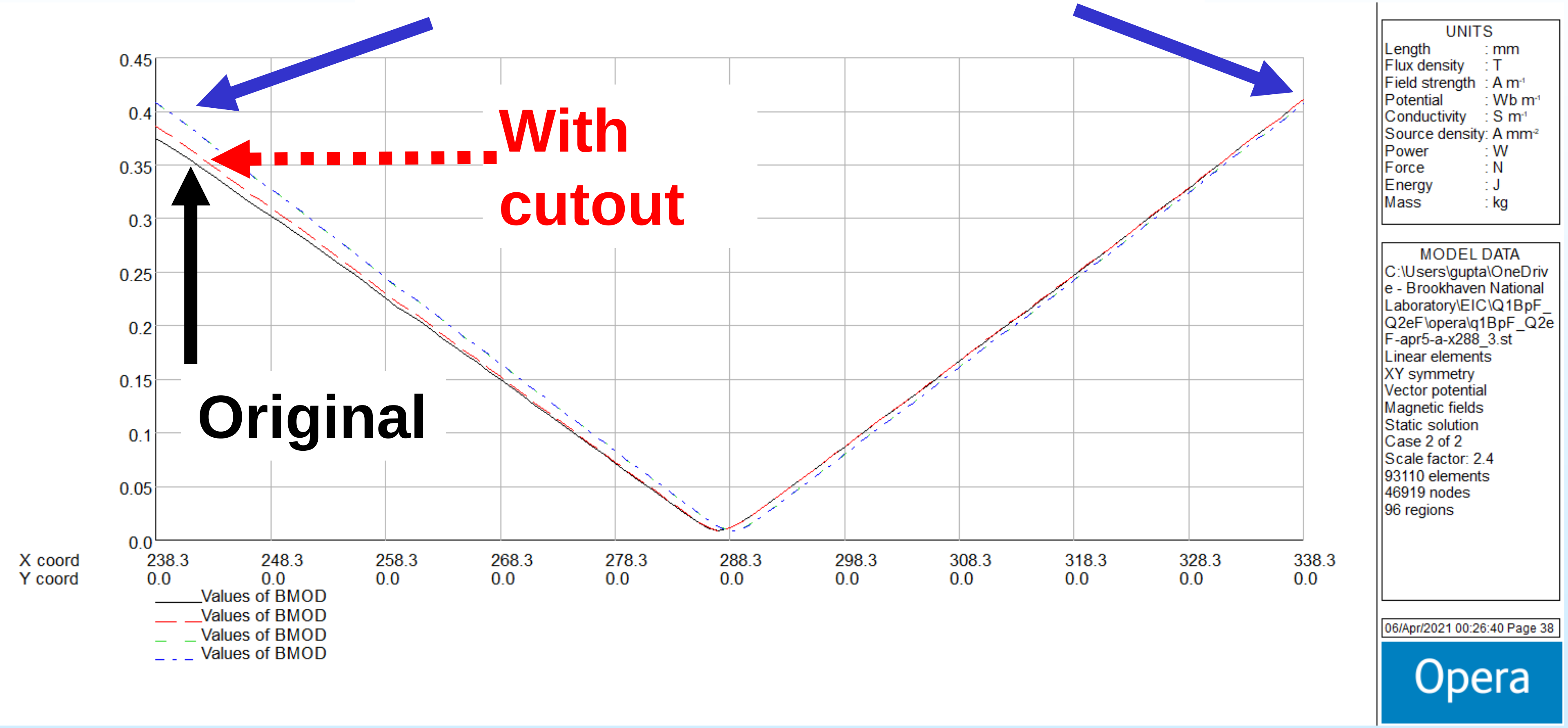






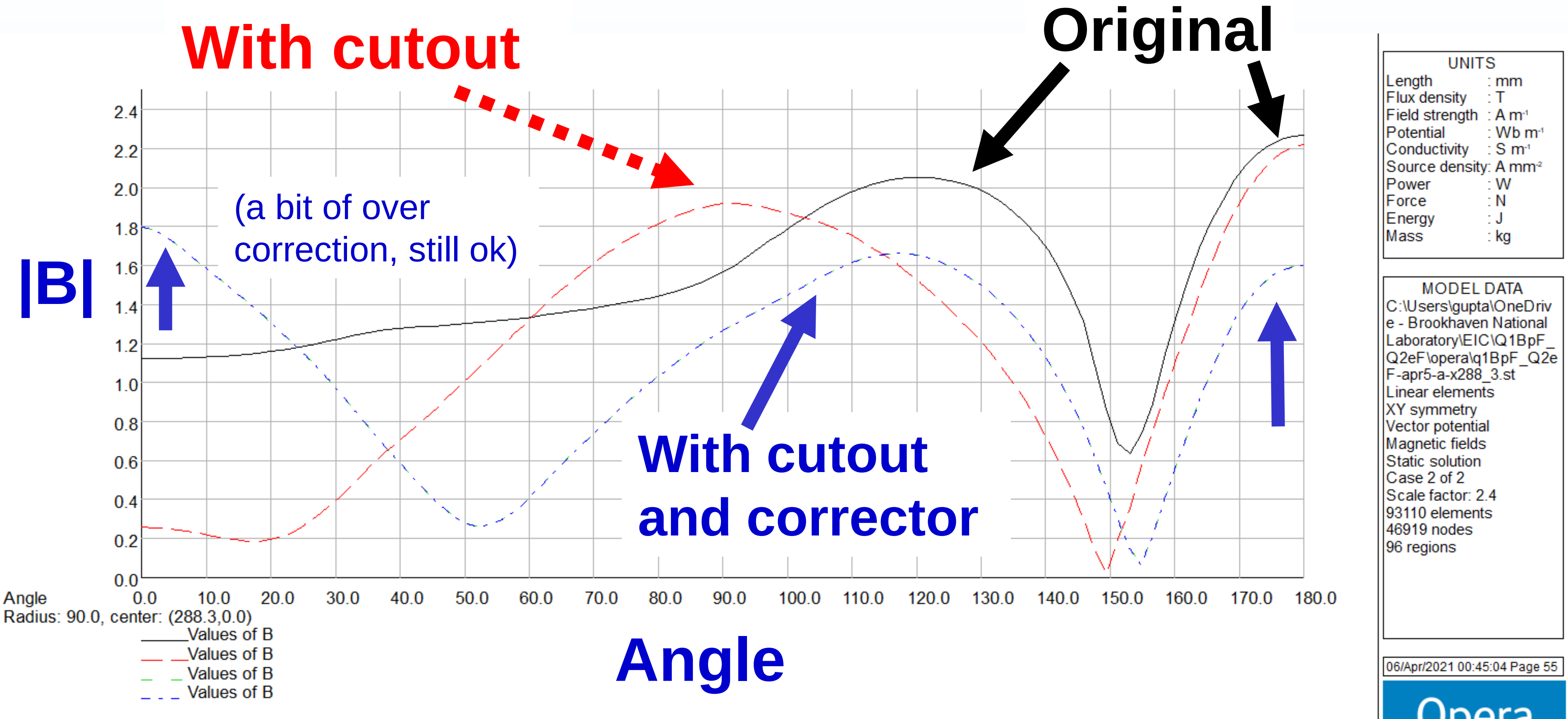
The Results: Compare the symmetry of the field on x-axis around the center

With cutout and corrector



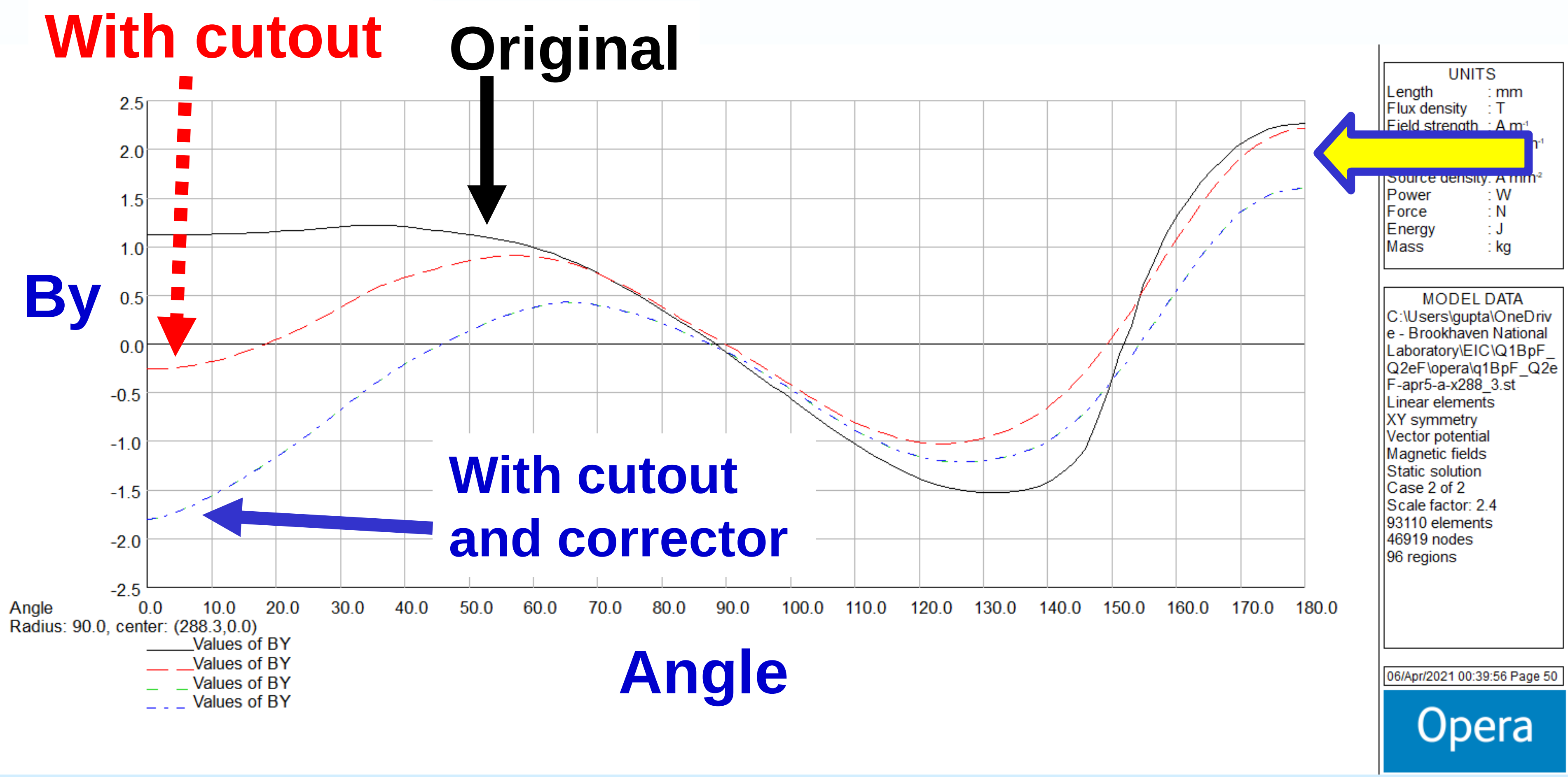
Note: Symmetry with cutout and corrector

The real action is in reducing the maximum field in the iron around Q1eF



Note: Reduction in the maximum field (2.2 T to 1.6 T) in the yoke at a radius of 90 mm

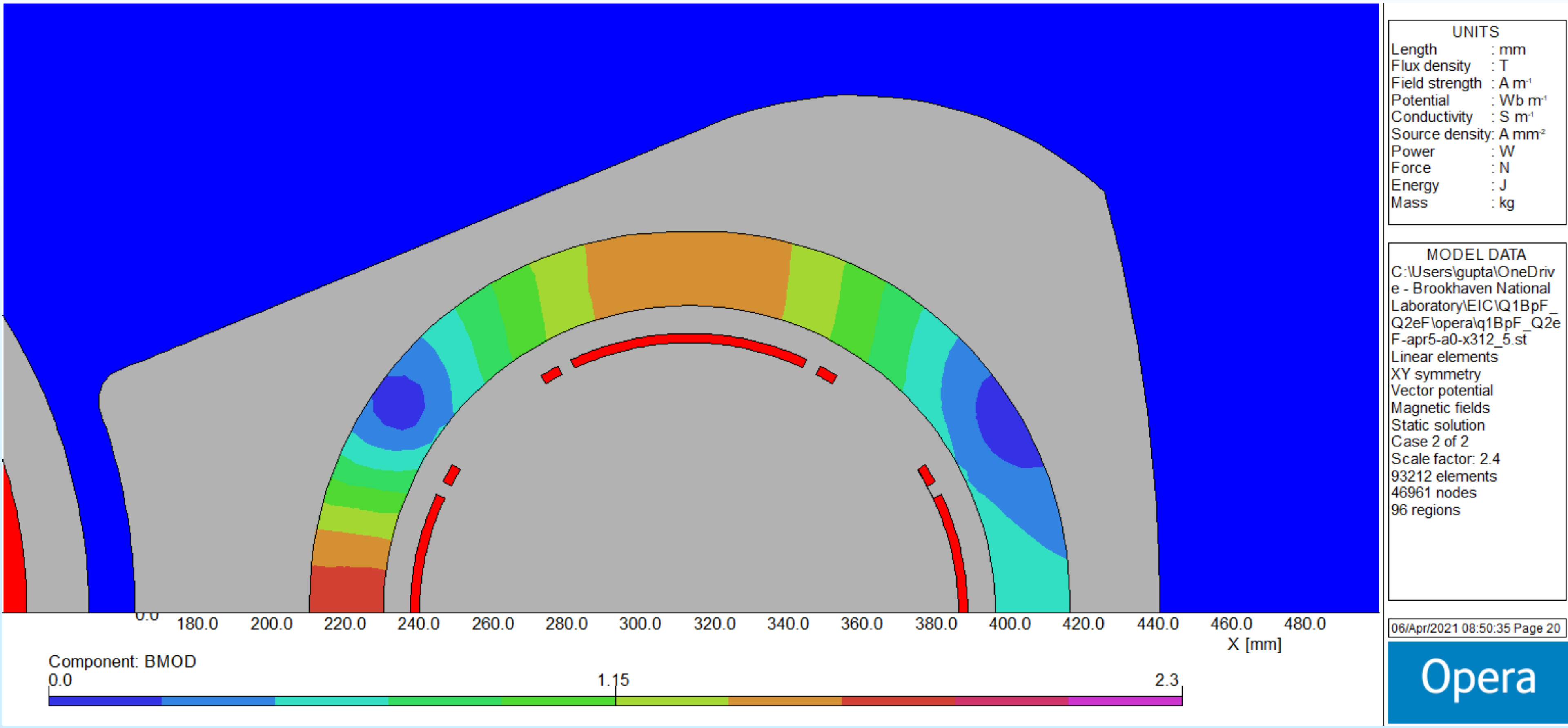
Even more dramatic is in reducing or shifting "By" in the iron around Q1eF



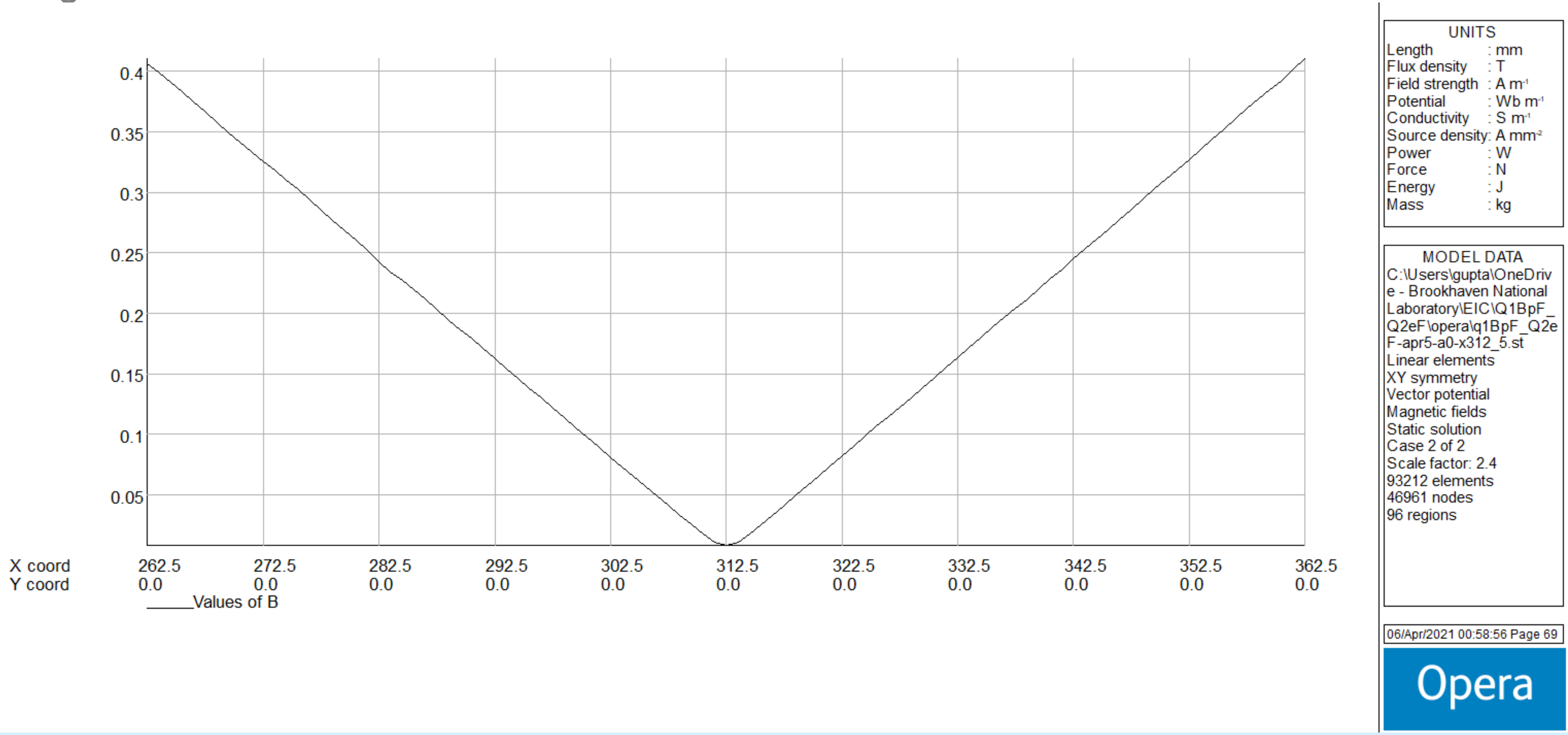
Note: Change or Shift in By (angle=0 on right side)

Situation at the other end

Field in the yoke around Q1eF appears to be low enough (~1.8 T) that we may get by with just cutout

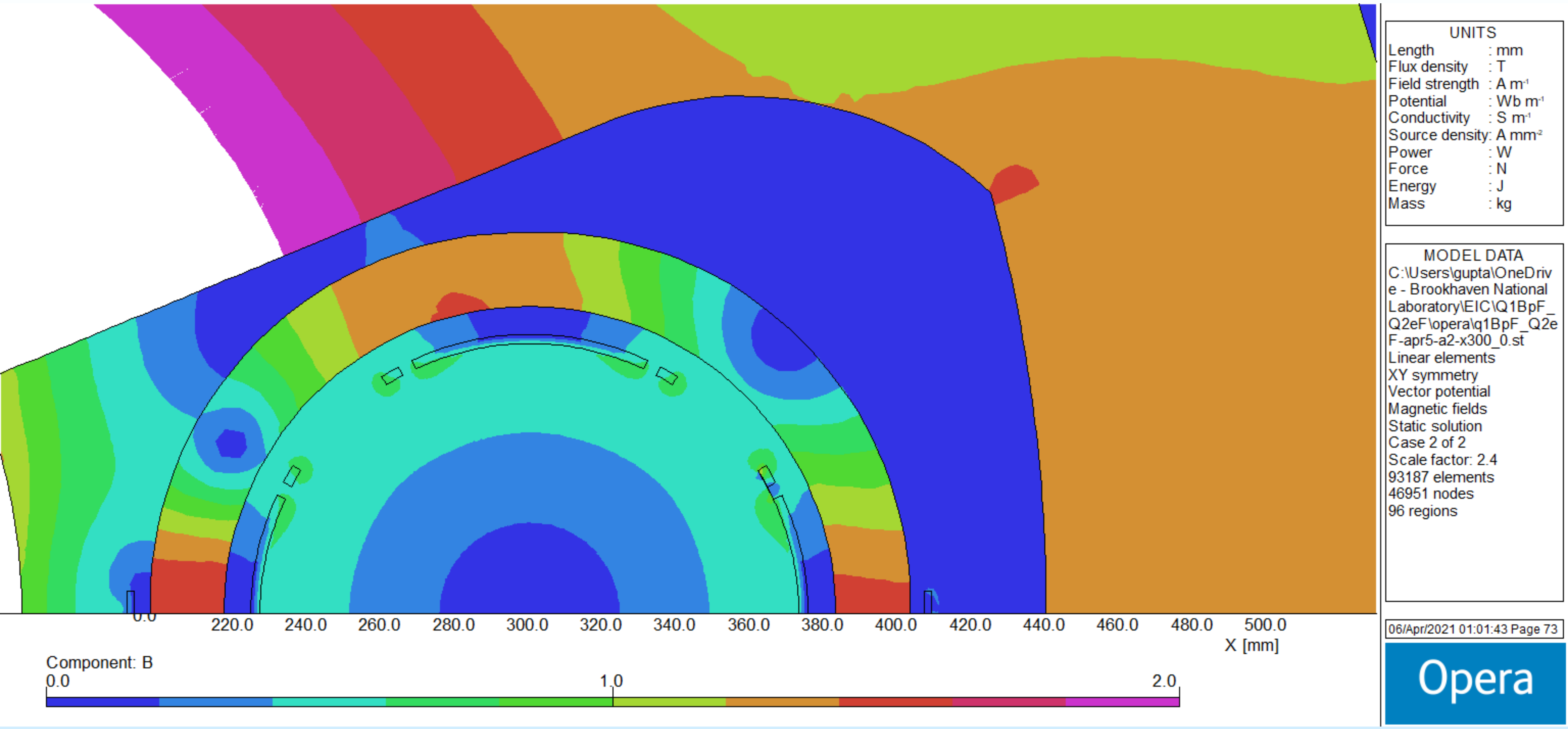


Situation at the other end



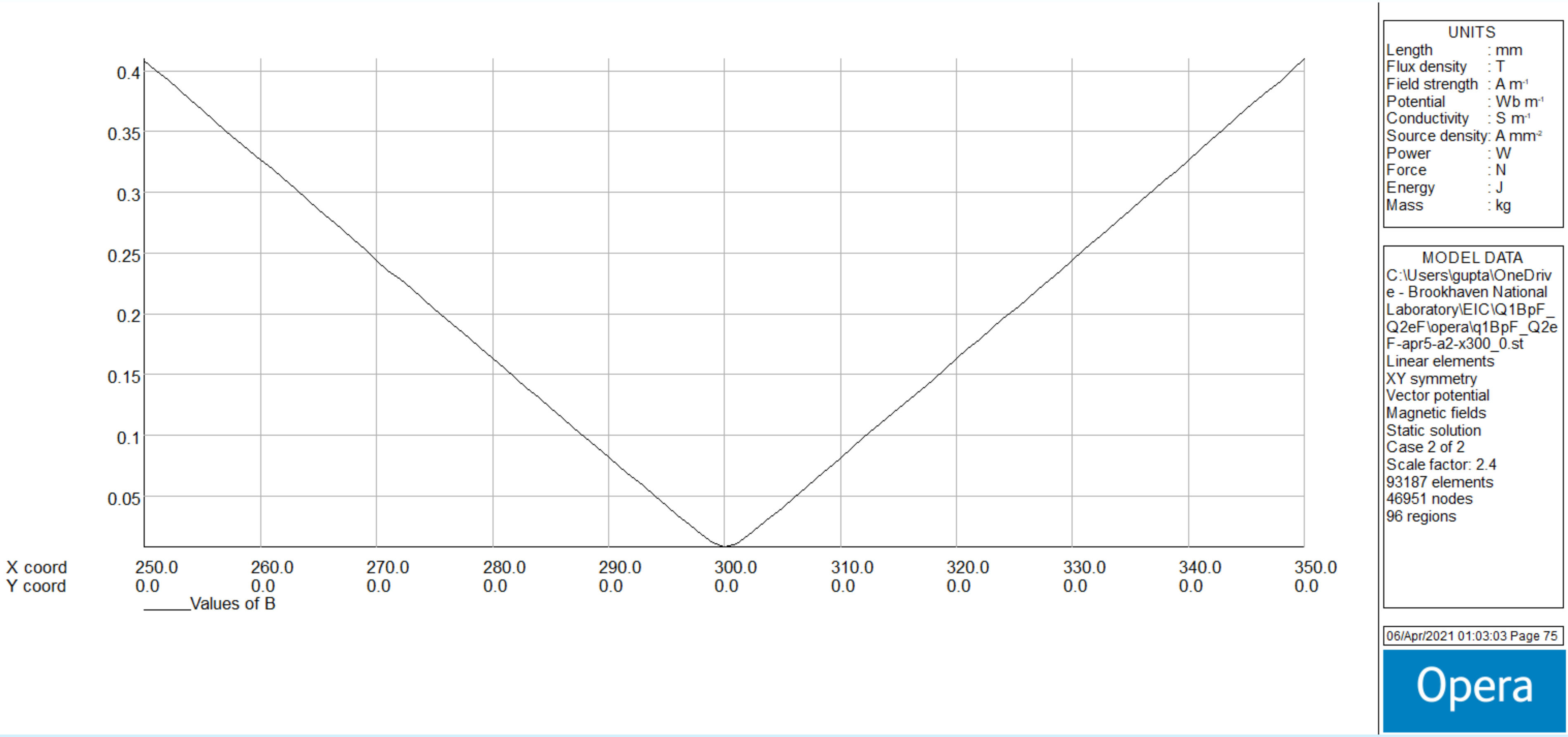
Field on the x-axis is symmetric around the center (x0=312.5). We can get by with just with cutout in the yoke (no corrector needed)

Situation in the Middle



Field in the yoke around Q1eF with reduced strength of the corrector

Situation in the Middle



Field on the x-axis is symmetric around the center (x0=300 mm) with cutout & reduced strength of corrector

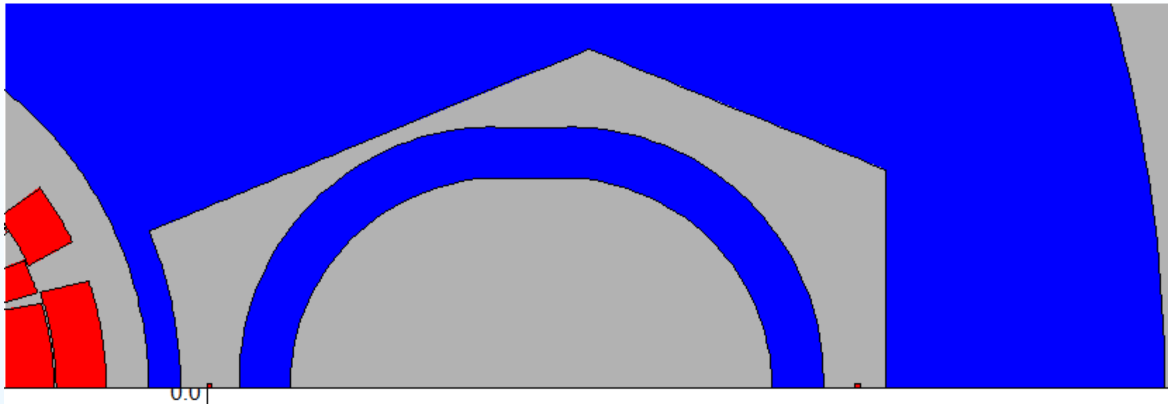
Summary

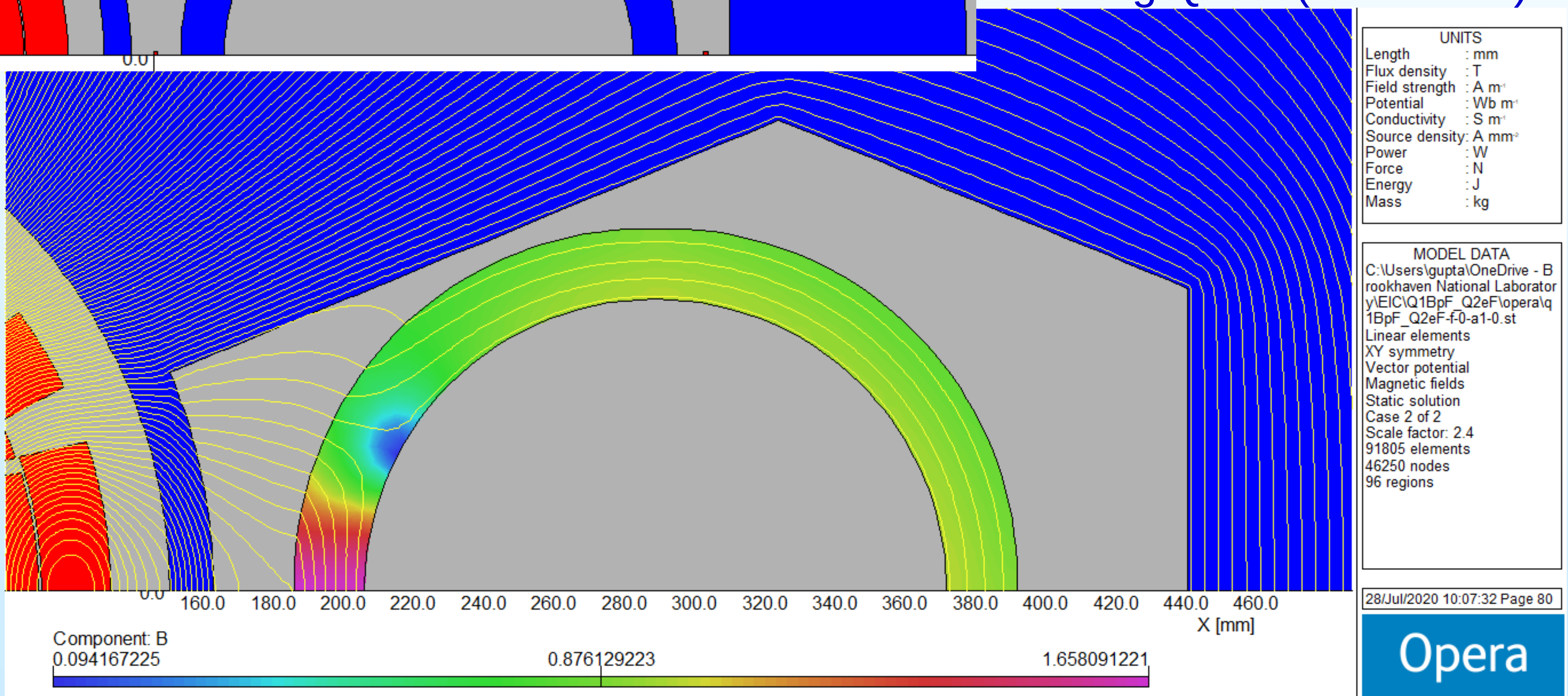
- **A novel technique is being developed to reduced cross-talk on tight space (cutout and controlling iron saturation with small additional coils).**
- **It is based on controlling the yoke saturation (experience from RHIC magnets - now standard around the world), where we reduced saturation from 40+ unit of sextupole to just a few units.**
- **The corrector strength (or number of turns) needs to be adjusted in going from the one end (maximum) to the other end (none).**

Backup Slides (from last year)

Q1BpF with Q1eF (need to remove flat-top)

Flat-top creates non-allowed harmonics and takes away iron from the return yoke. therefore, it is removed for inserting Q1eF (see below)





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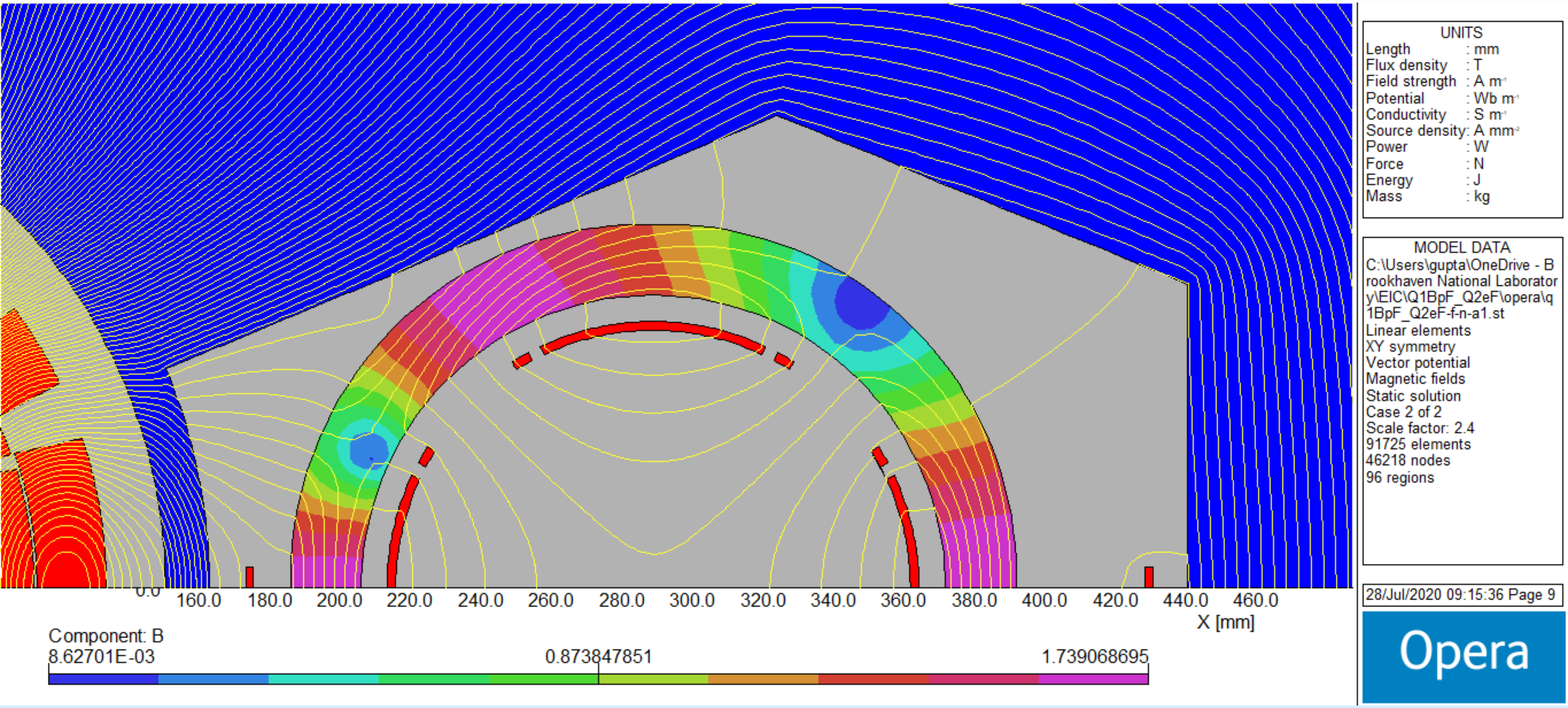
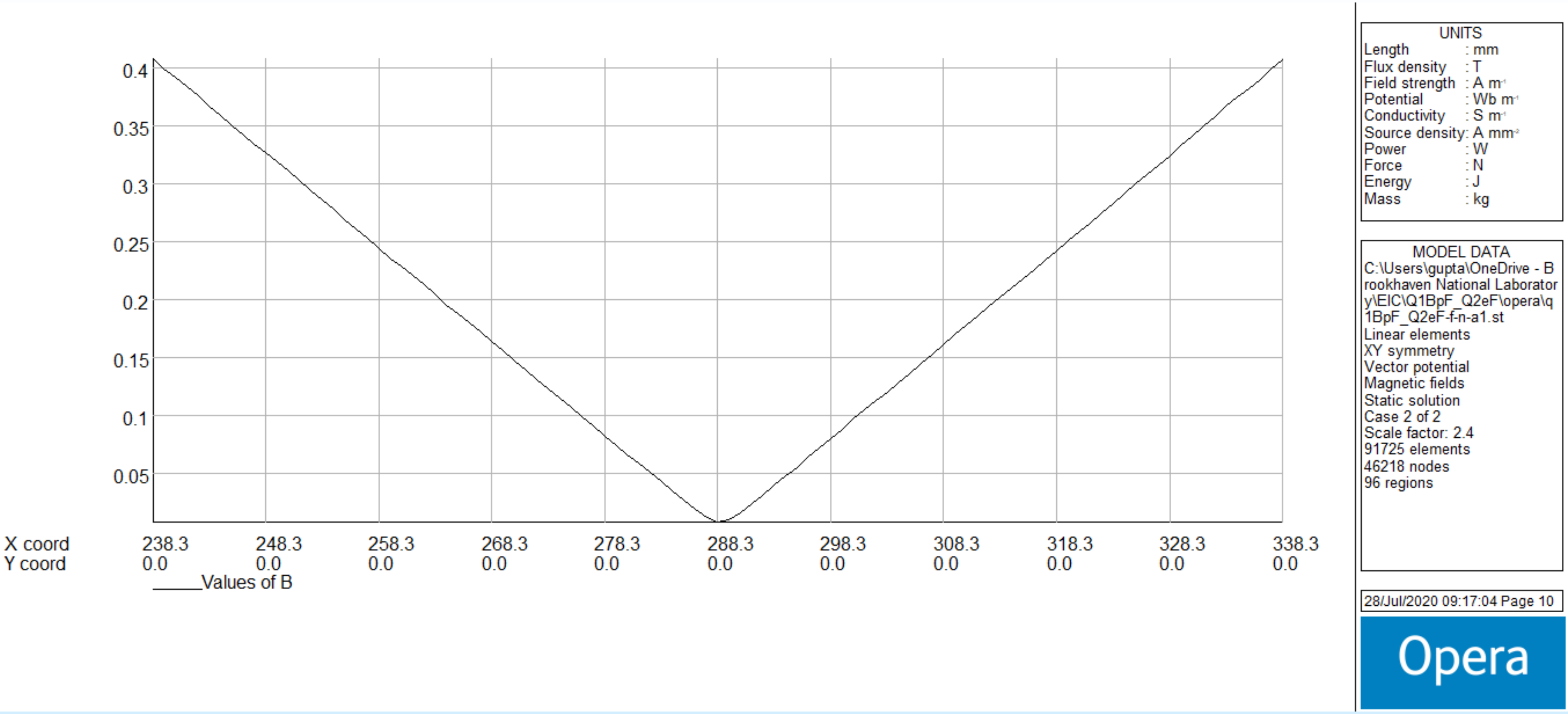
Q1BpF (Q1eF with opposite polarity AND stronger control coils)



Looks better as the iron providing the shielding is less saturated (1.7 T rather than over 2 T)

Q1BpF (Q1eF with opposite polarity AND stronger control coils)



Still looks good as gradient is symmetric around the center of Q1eF (x=288.3)

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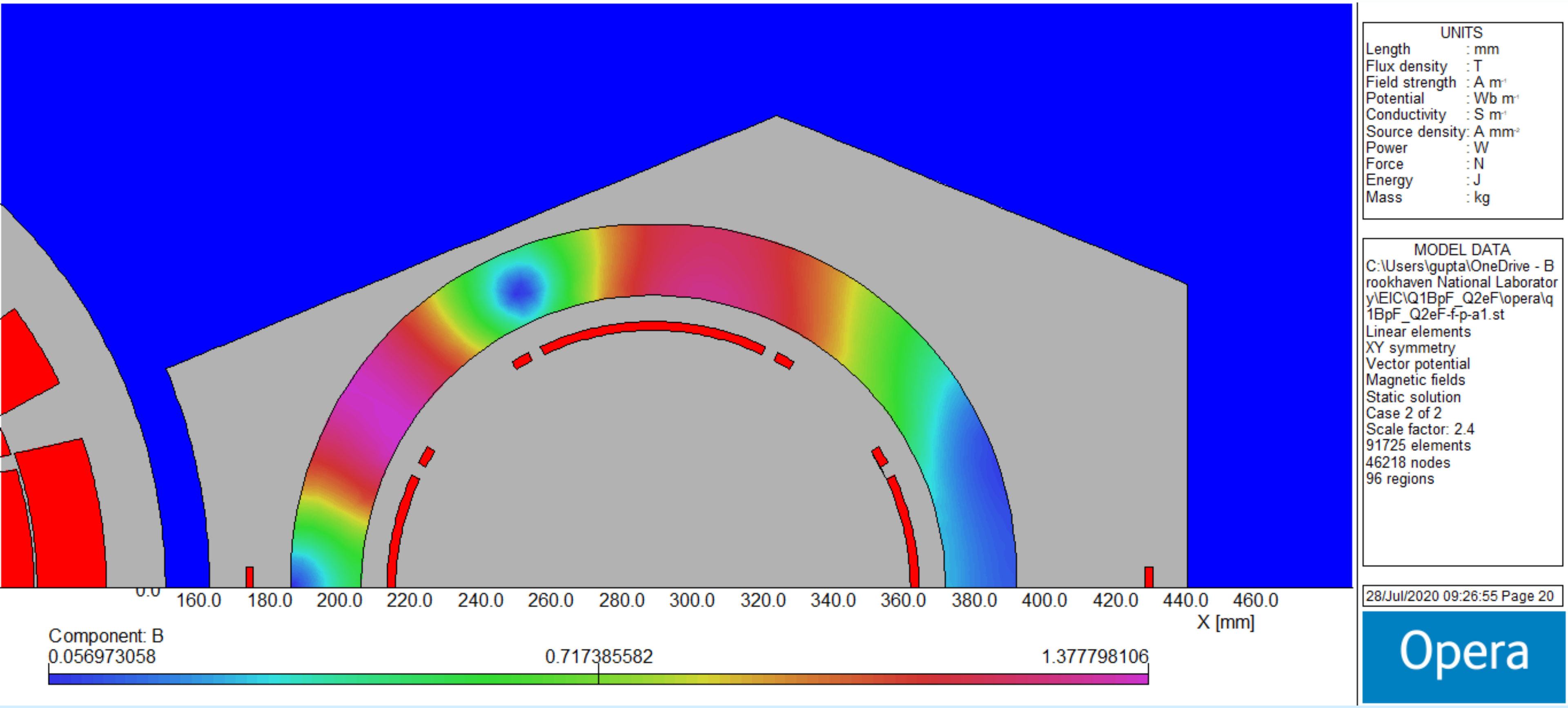
Q1BpF (Q1eF with good polarity AND stronger control coils)



Looks good as the iron providing the shielding is less saturated (1.3 T)