International MUON Collider Collaboration

# SC steady magnet concept and design studies

T. Maiello[1,2], L. Alfonso [1], A. Bersani[1], L. Bottura[3], B. Caiffi[1], S. Fabbri[3], S. Farinon[1], A. Gagno[1,2] , D. Novelli[1,4] , A. Pampaloni[1]

*[1] INFN – Genova, [2] Università degli Studi di Genova, [3] CERN, [4] Sapienza Università di Roma*

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# ACCELERATOR SUPERCONDUCTING MAGNETS

## Main characteristics:

- **Open midplane dipole**
- **10 T** in the bore
- Rectangular aperture **100 mm x 30 mm**
- Field quality: $b_n < 10$ units in beam radius of **10 mm**
- Field **homogeneity** $\leq$ 1% in the good field region

**Fukjikura cable**

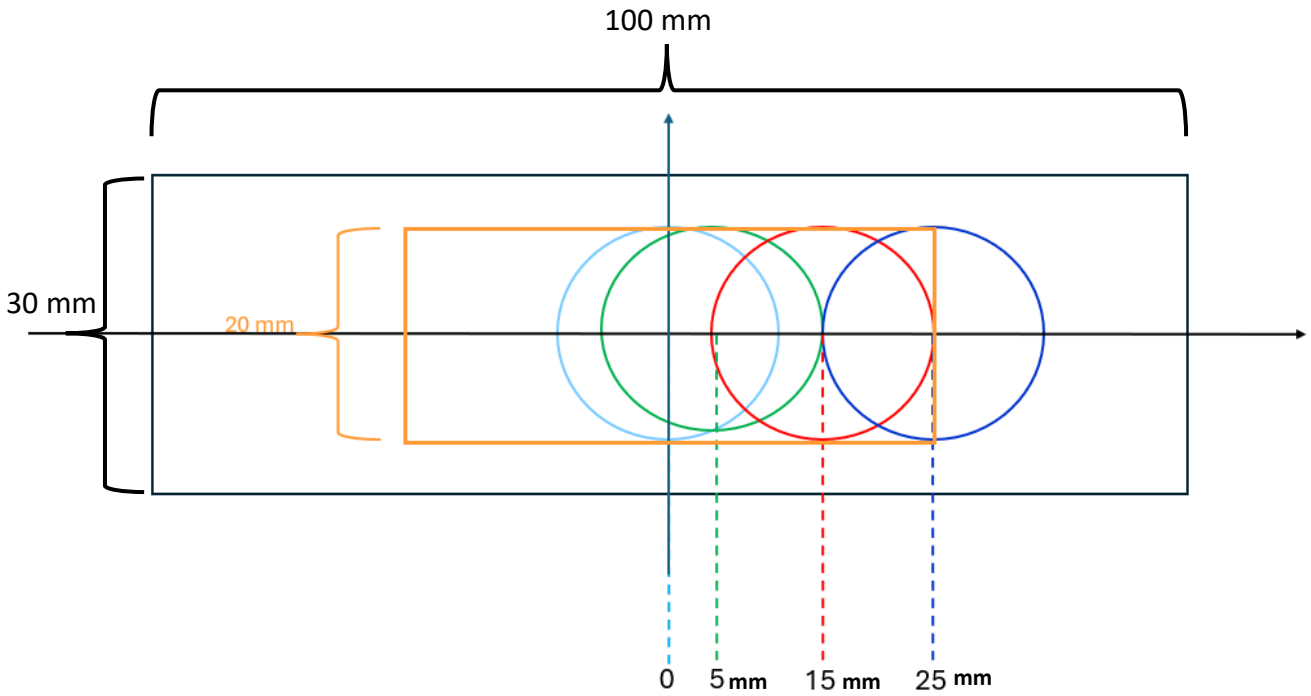
| HTS cable properties | |
|---|---|
| Bare height [mm] | 12.00 |
| Bare width [mm] | 1.65 |
| Insulation [mm] | 0.10 |
| Number of tapes | 15 |

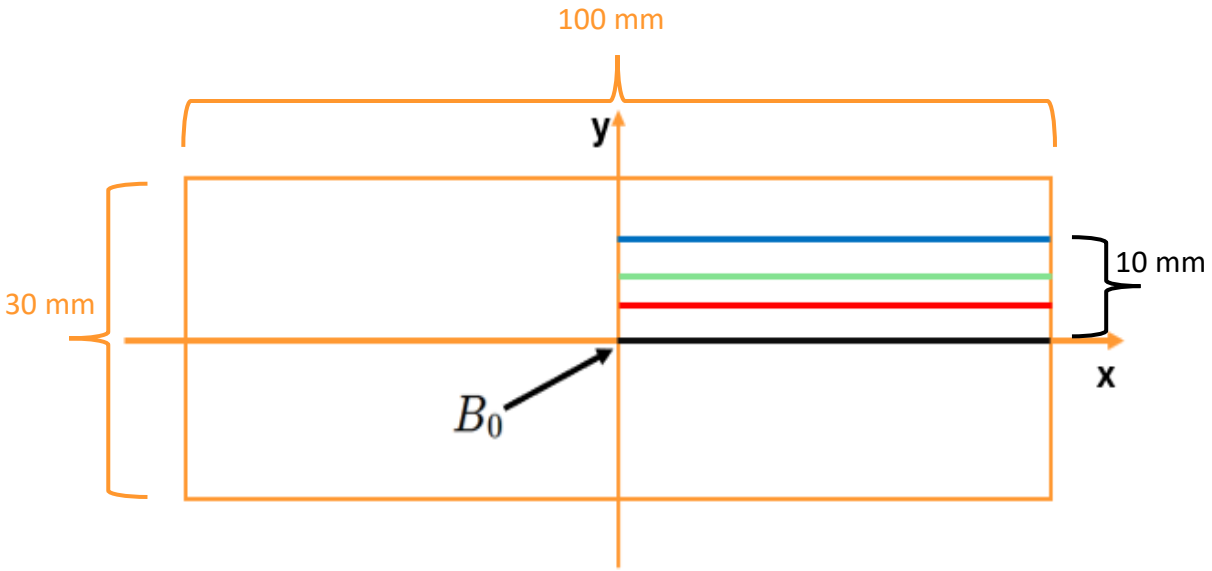
## Considerations:

- HTS windings
- High current density
- Operation at high temperature

# FIELD QUALITY AND HOMOGENEITY EVALUATION

- The field quality was evaluated in four harmonic coils with a radius 10mm in order to cover the affected portion of the aperture.
- Field homogeneity was calculated in a rectangular area of 10mm height and 50mm width.




$$\text{Homogeneity} = \frac{B_{MAX} - B_{MIN}}{B_0}$$

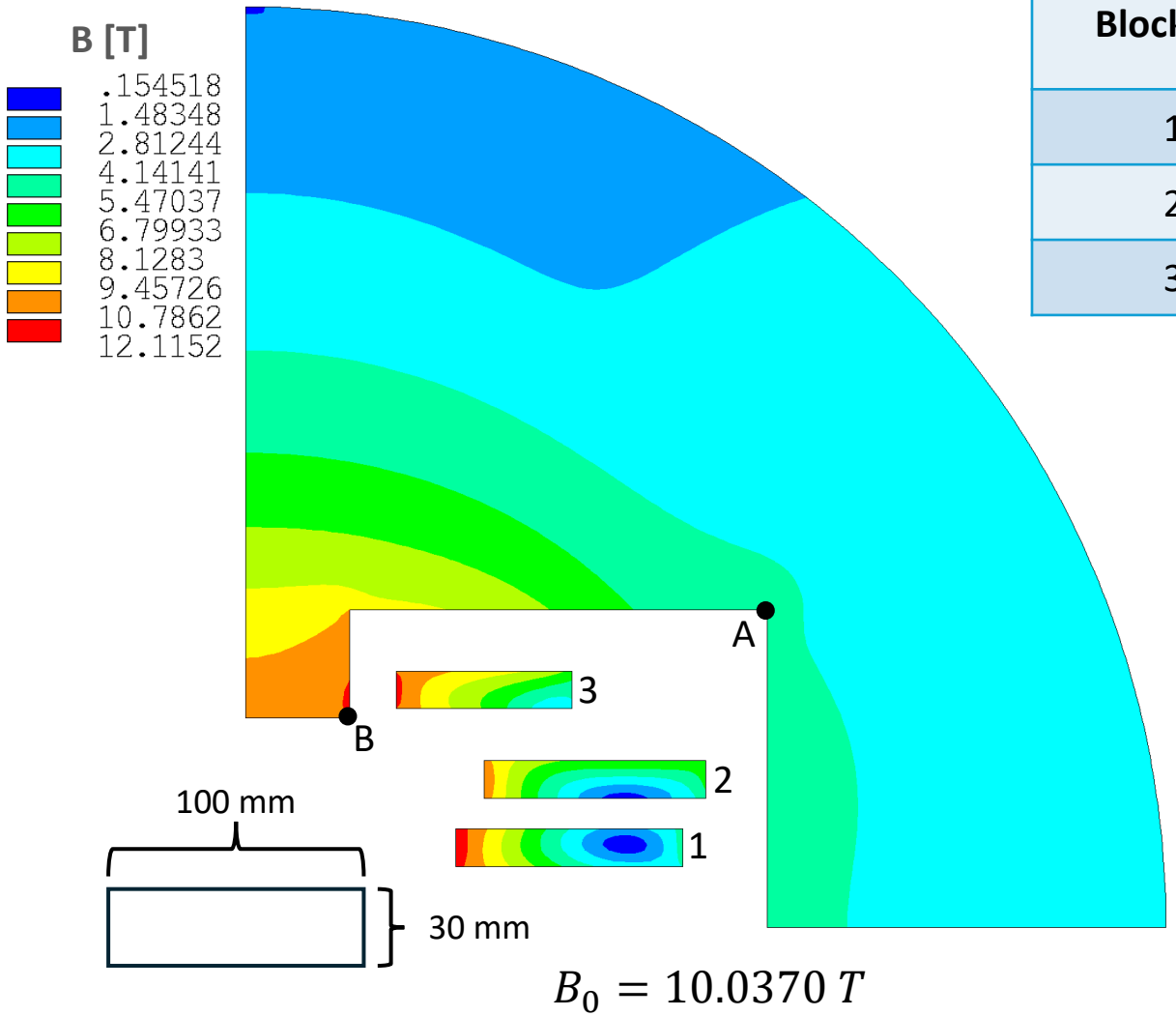
# CONFIGURATIONS

We have realized two 10 T configurations:

- Configuration 1: the first one has a very good field quality but is more difficult to realize for mechanical reasons because the blocks are not aligned;

- Configuration 2: the second one has two aligned racetracks but has a worse field quality.

# CONFIGURATION 1 @ 10 T



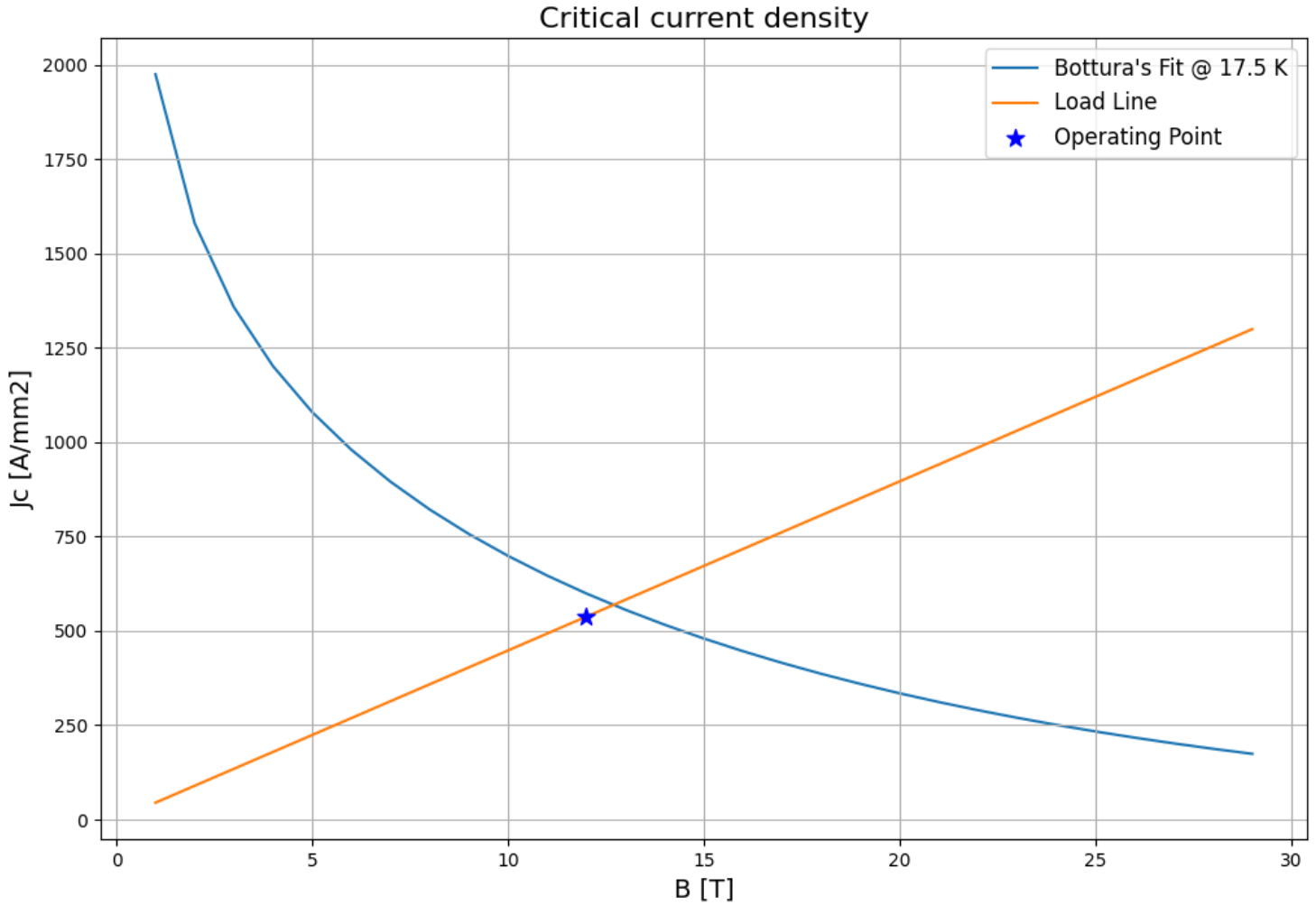

$B_0 = 10.0370\ T$

| Block no. | X [mm] right lower corner | Y [mm] right lower corner | No. of conductors | No. of tapes |
|---|---|---|---|---|
| 1 | 142.6 | 20.0 | 40 | 600 |
| 2 | 150.0 | 42.2 | 39 | 585 |
| 3 | 106.4 | 71.4 | 31 | 465 |

| Iron yoke | |
|---|---|
| Radius [mm] | 300 |
| A [mm] | (170.0; 103.6) |
| B [mm] | (34.1; 68.4) |

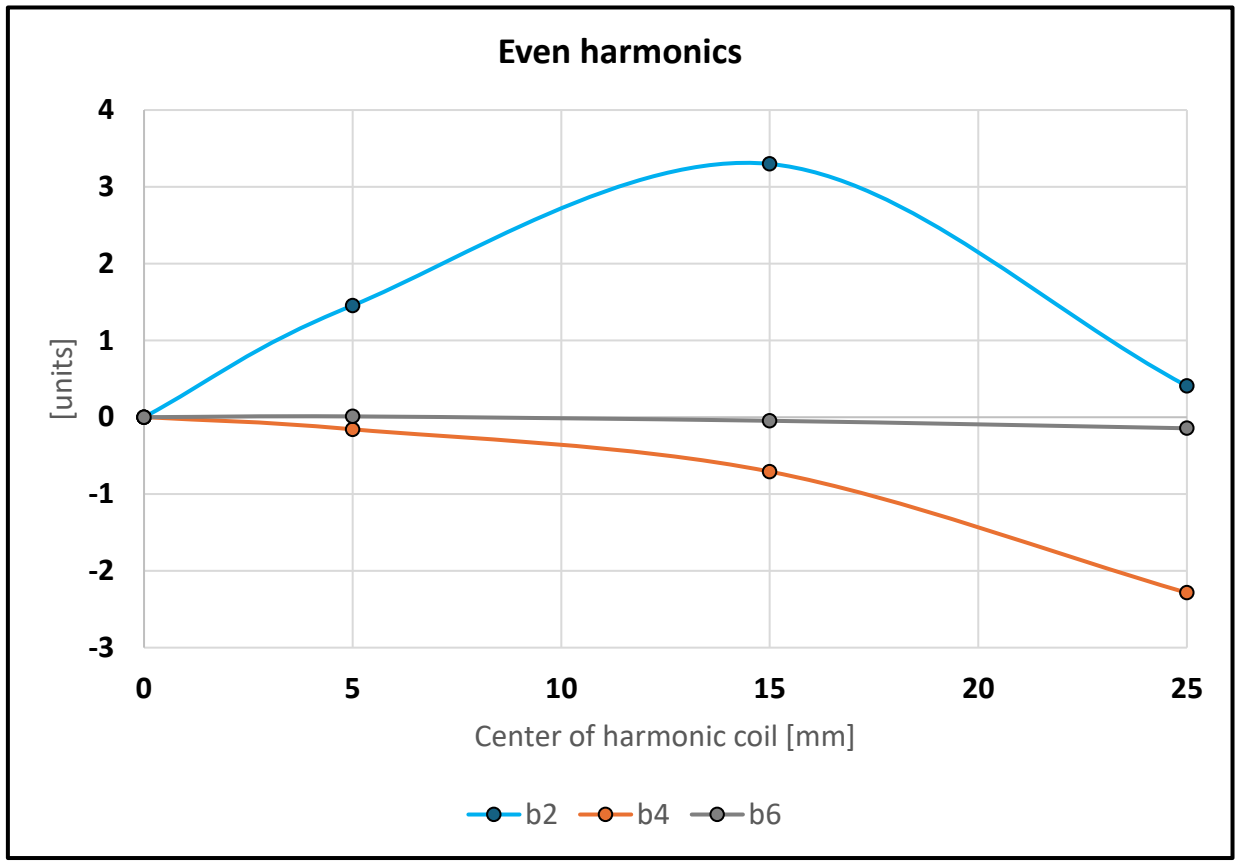
| | |
|---|---|
| **Tot. Structure [k€/m]** | 25.9 |
| **Tot. Assembly [k€/m]** | 20.0 |
| **Tot. Conductor [k€/m]** | 127.1 |
| **Tot. Cost [k€/m]** | 173.0 |

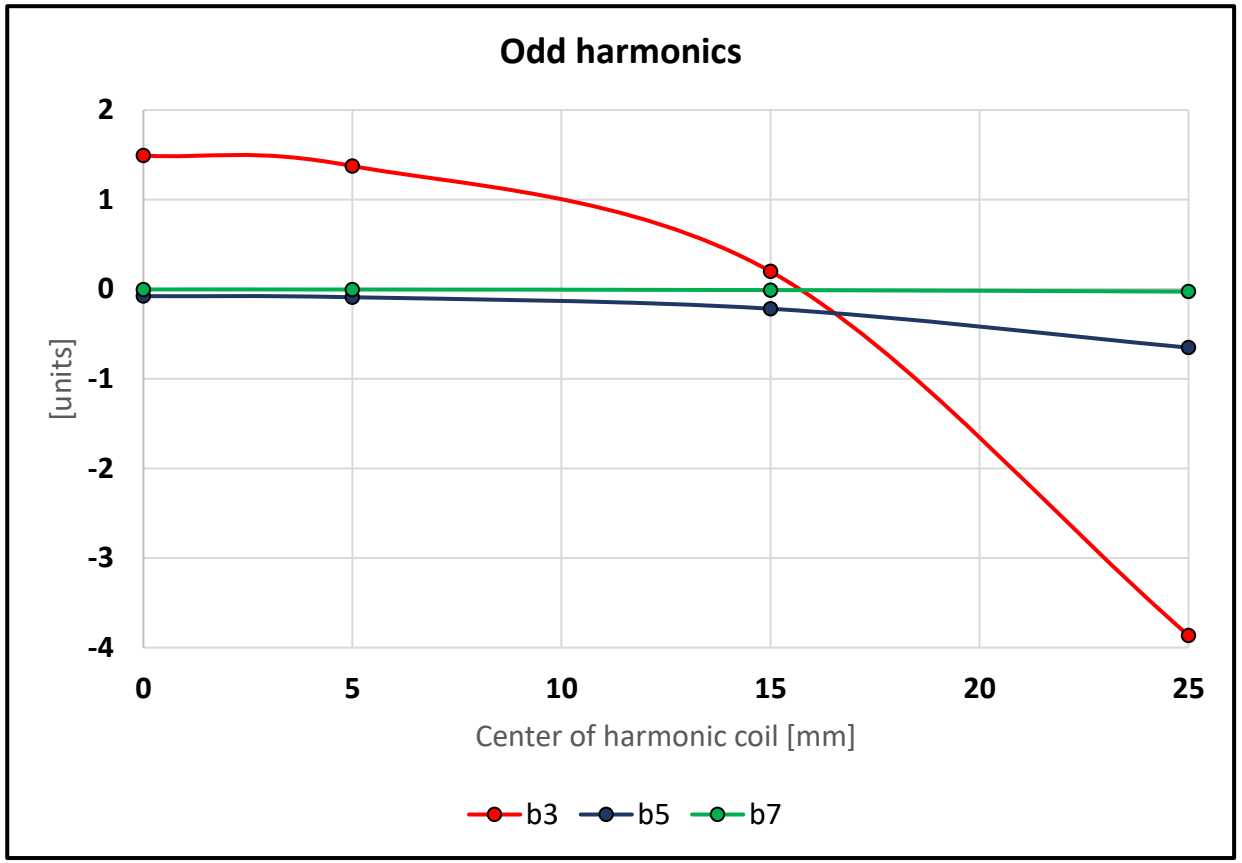
# CONFIGURATION 1 @ 10 T




| | |
|---|---|
| **Operative temperature [K]** | 17.5 |
| **Margin [K]** | 2.5 |
| **Current [A]** | 12130 |
| **Current density [A/mm²]** | 537.44 |

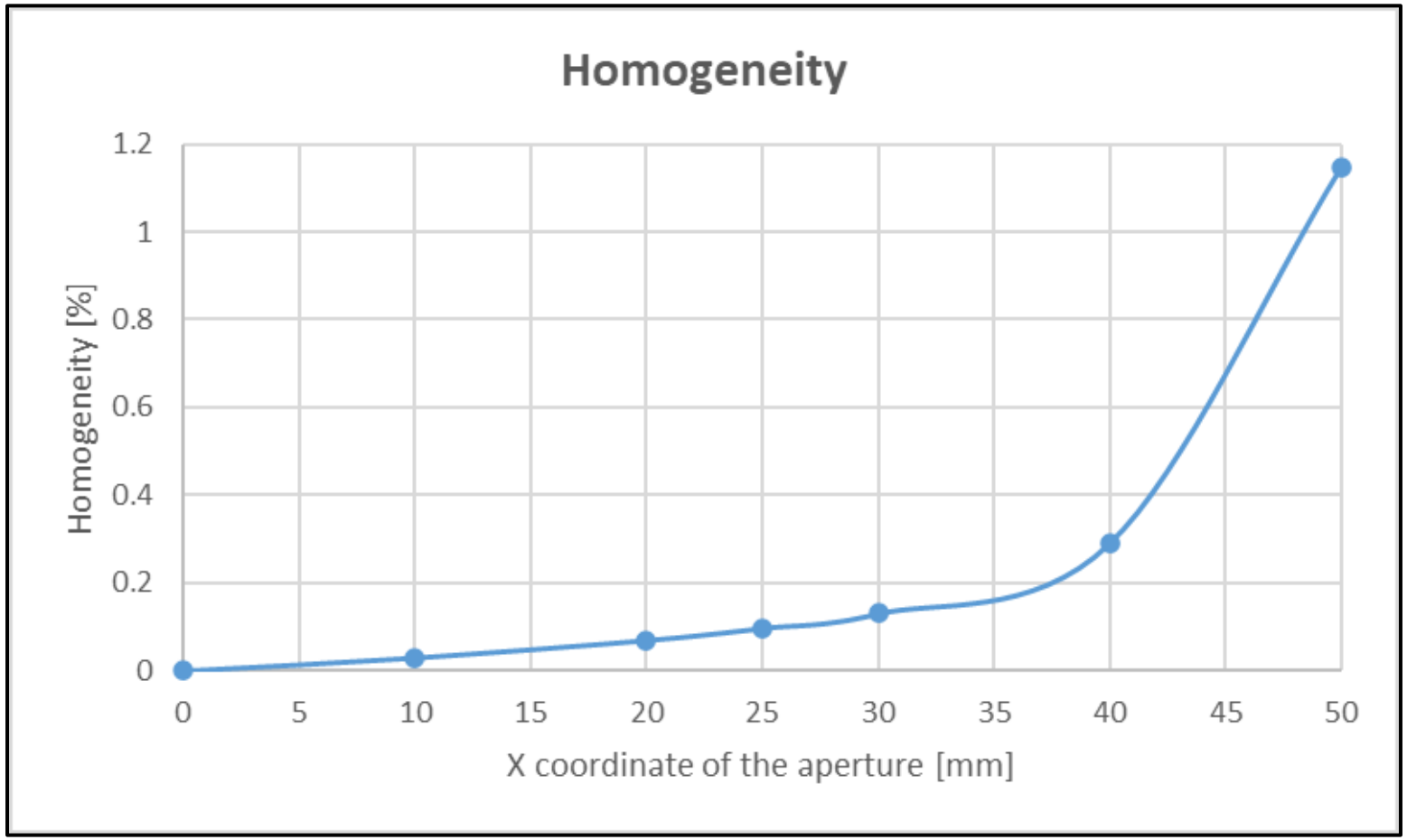
# CONFIGURATION 1 @ 10 T



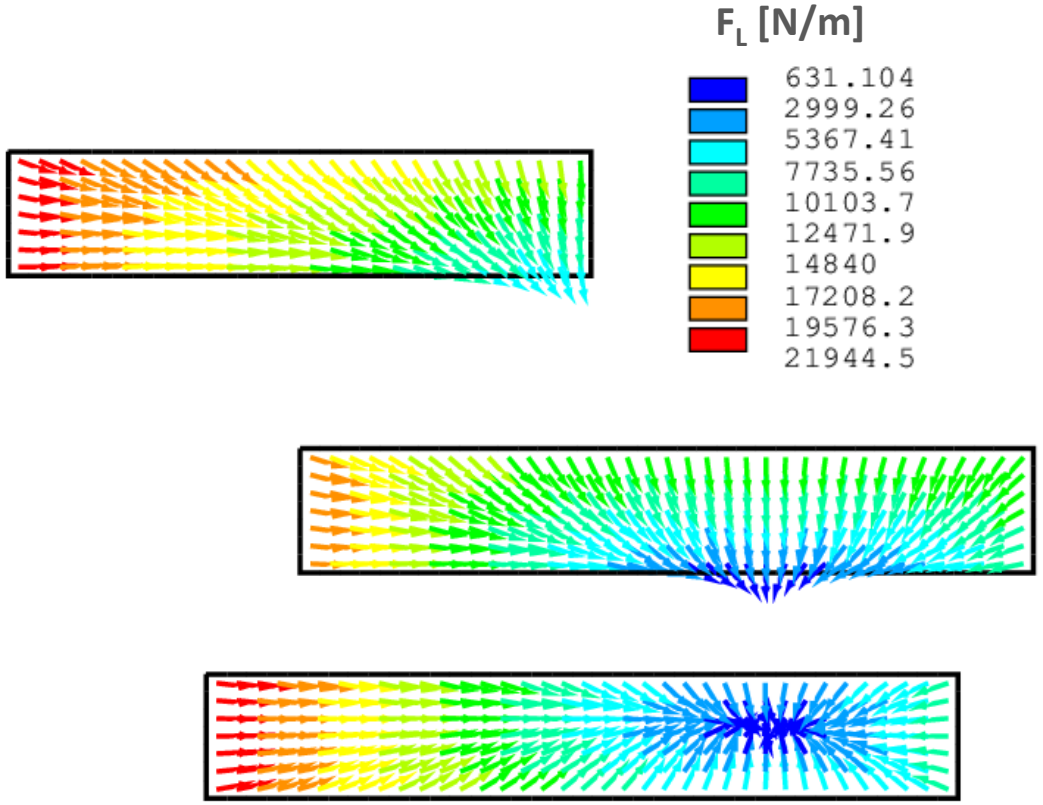

$$|b_n| < 0.003 \ (n \geq 8)$$

# CONFIGURATION 1 @ 10 T

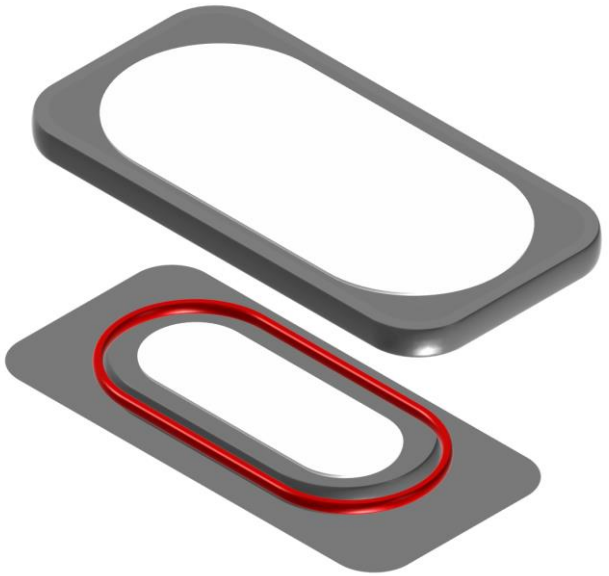



Homogeneity (x=25mm) = 0.097%

# CONFIGURATION 1 @ 10 T

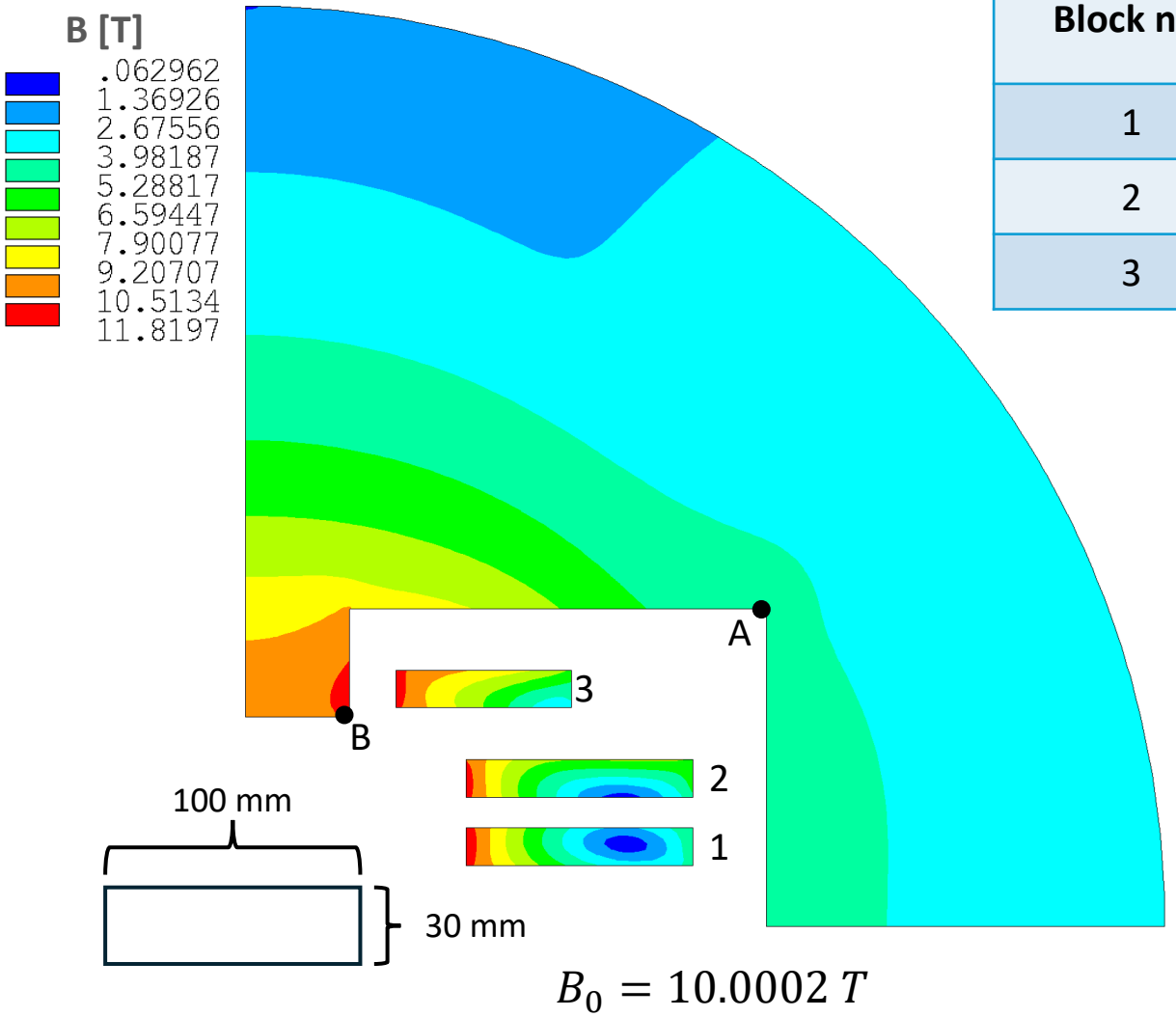



| Block no. | $F_x$ [kN/m] | $F_y$ [kN/m] |
|---|---|---|
| 1 | 1753 | 246 |
| 2 | 928 | -1433 |
| 3 | 2213 | -1288 |
| **TOTAL** | **4893** | **-2475** |



Preliminary concept: the mechanical structure we want to study consists of stainless steel containers to house racetracks. The sketch on the left is only an indication to understand the concept.

# CONFIGURATION 2 @ 10 T



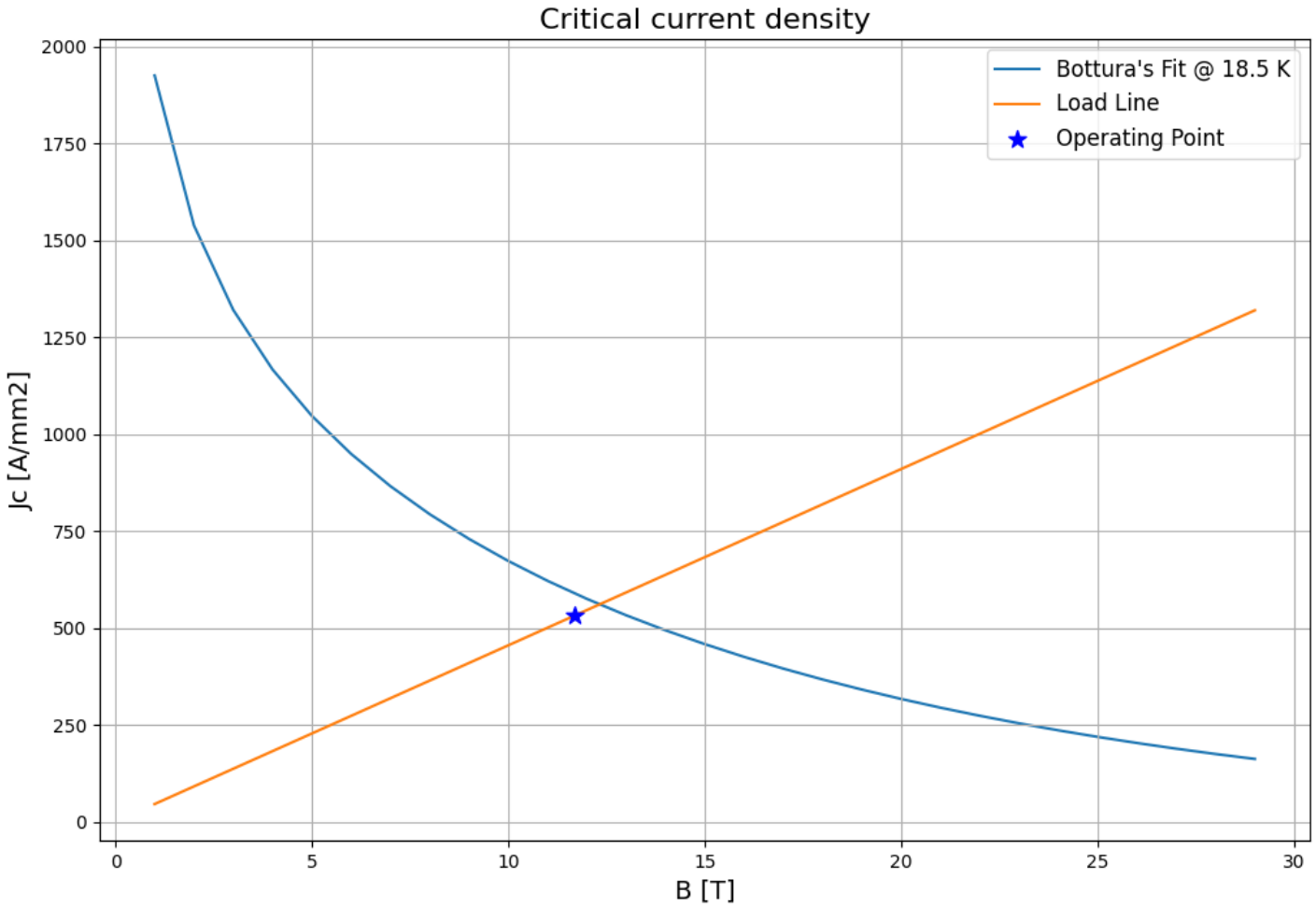

$B_0 = 10.0002\ T$

| Block no. | X [mm] right lower corner | Y [mm] right lower corner | No. of conductors | No. of tapes |
|---|---|---|---|---|
| 1 | 146.0 | 20.0 | 40 | 600 |
| 2 | 146.0 | 42.2 | 40 | 600 |
| 3 | 106.4 | 71.4 | 31 | 465 |

| Iron yoke | |
|---|---|
| Radius [mm] | 300 |
| A [mm] | (170.0; 103.6) |
| B [mm] | (34.1; 68.4) |

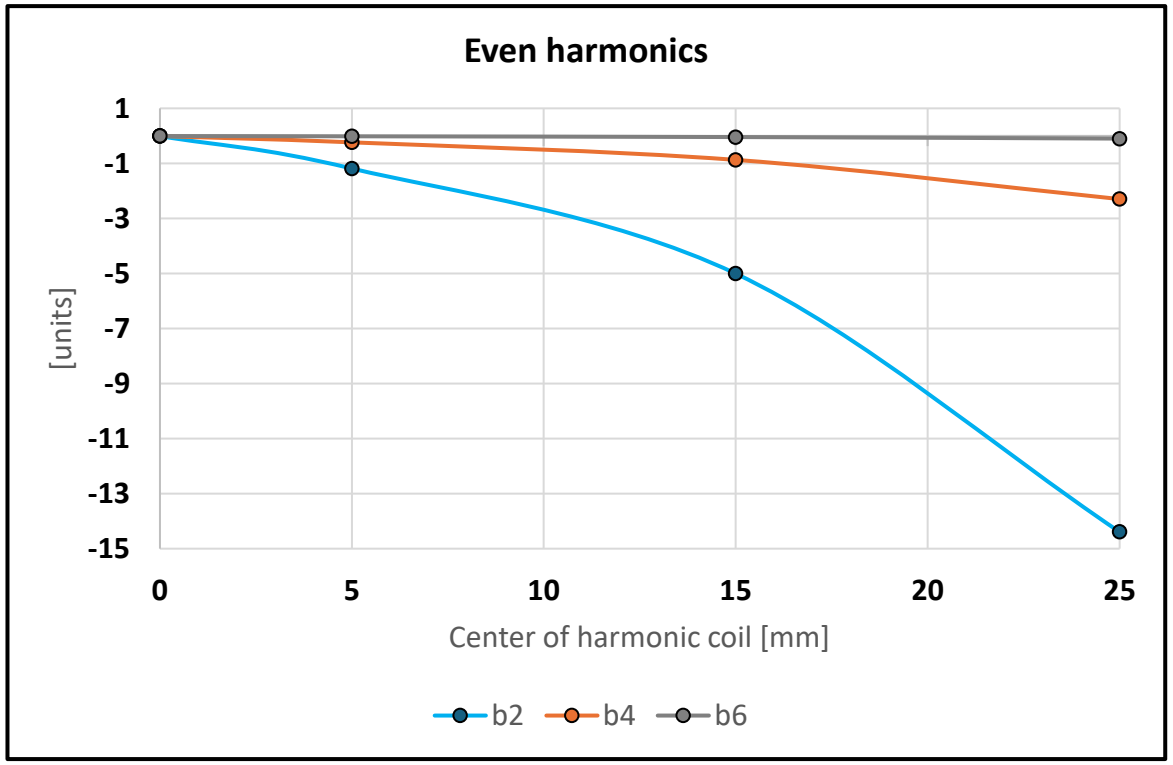
| | |
|---|---|
| **Tot. Structure [k€/m]** | 25.9 |
| **Tot. Assembly [k€/m]** | 20.0 |
| **Tot. Conductor [k€/m]** | 128.3 |
| **Tot. Cost [k€/m]** | 174.2 |

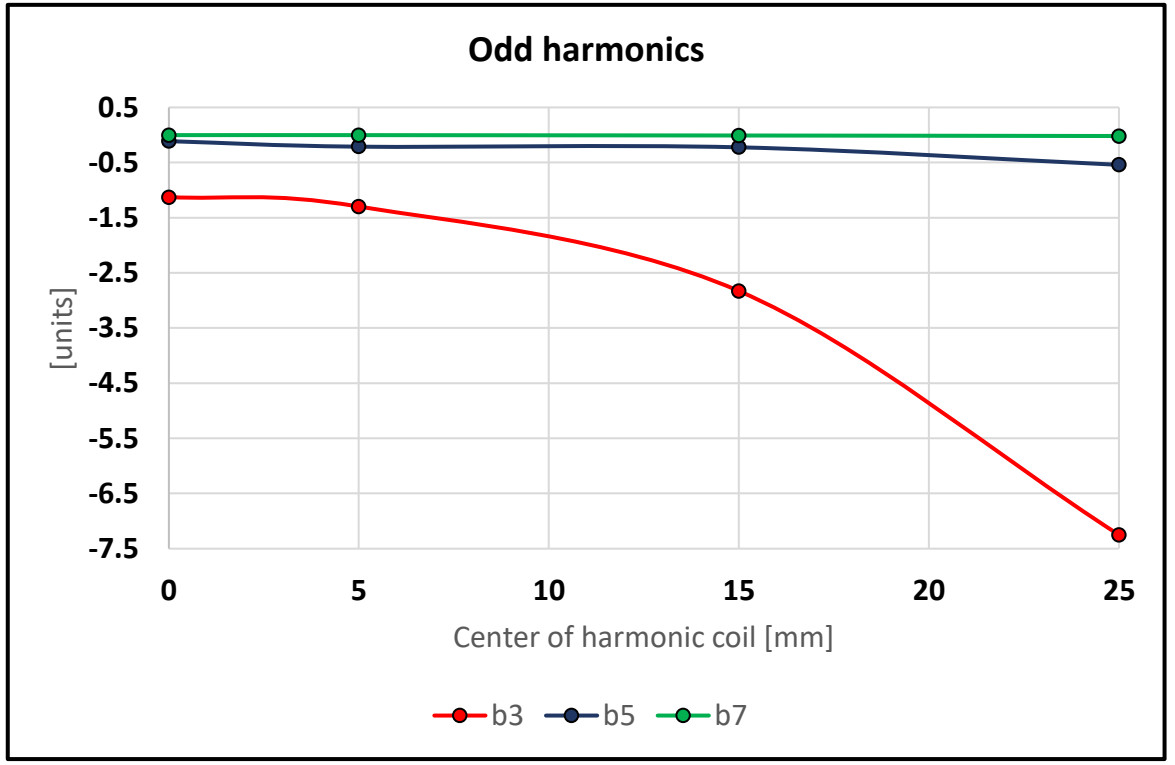
# CONFIGURATION 2 @ 10 T




| | |
|---|---|
| **Operative temperature [K]** | 18.5 |
| **Margin [K]** | 2.5 |
| **Current [A]** | 12000 |
| **Current density [A/mm²]** | 531.68 |

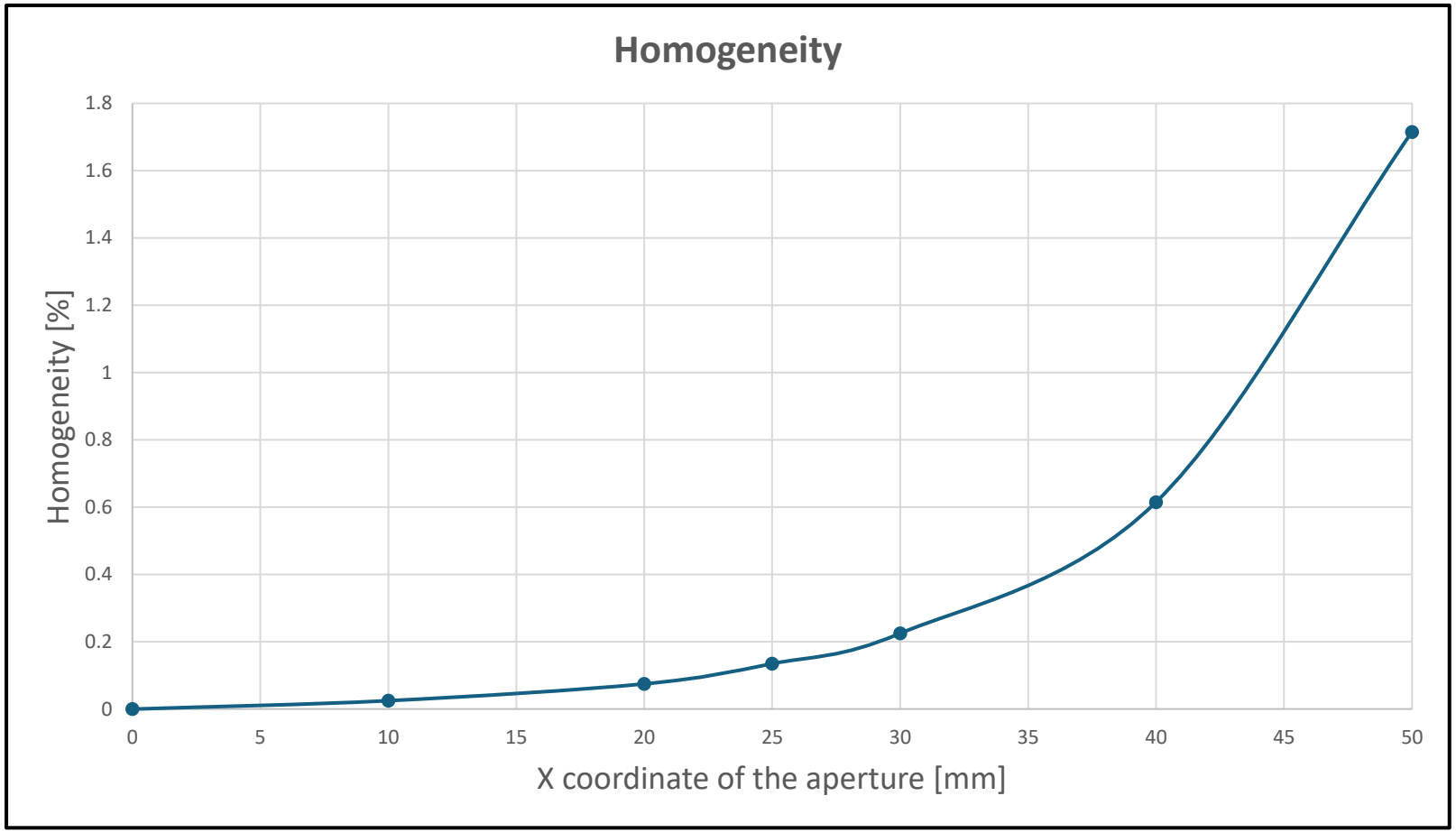
# CONFIGURATION 2 @ 10 T




$$|b_n| < 0.003 \ (n \geq 8)$$

# CONFIGURATION 2 @ 10 T




Homogeneity (x=25mm) = 0.13%

# CONCLUSIONS

- We were able to find a solution for an open midplane dipole that generates 10T in the center with excellent homogeneity and good field quality.

- There are simpler solutions for mechanics with good homogeneity but loosing in terms of field quality.

# Thank you for your attention!

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