TÉCNICO LISBOA

HTS 2018 MODELLING

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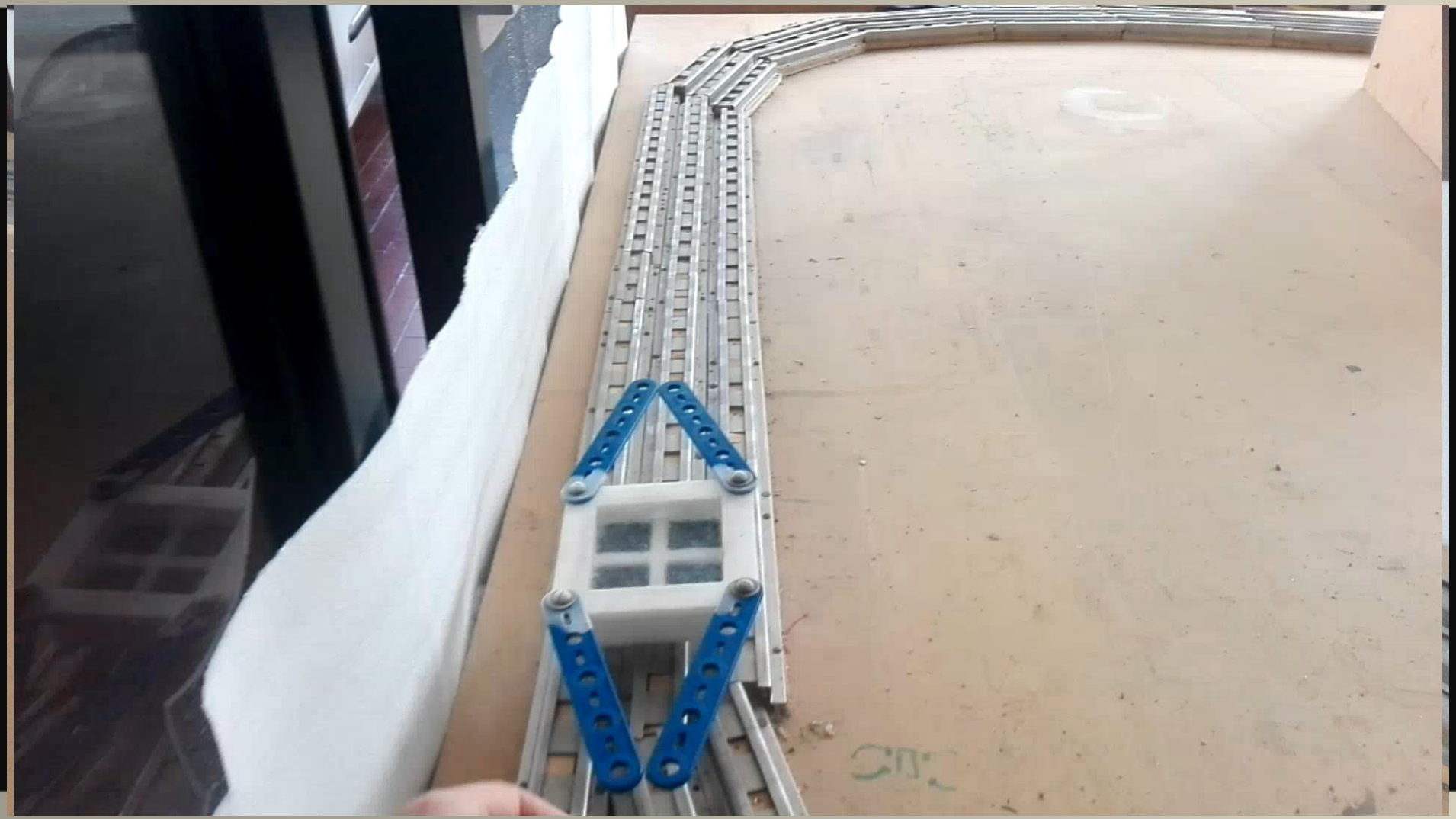
Study of a Cylindrical Geometry Design for the ZFC-Maglev System

Francisco Silva & P.J. Costa Branco

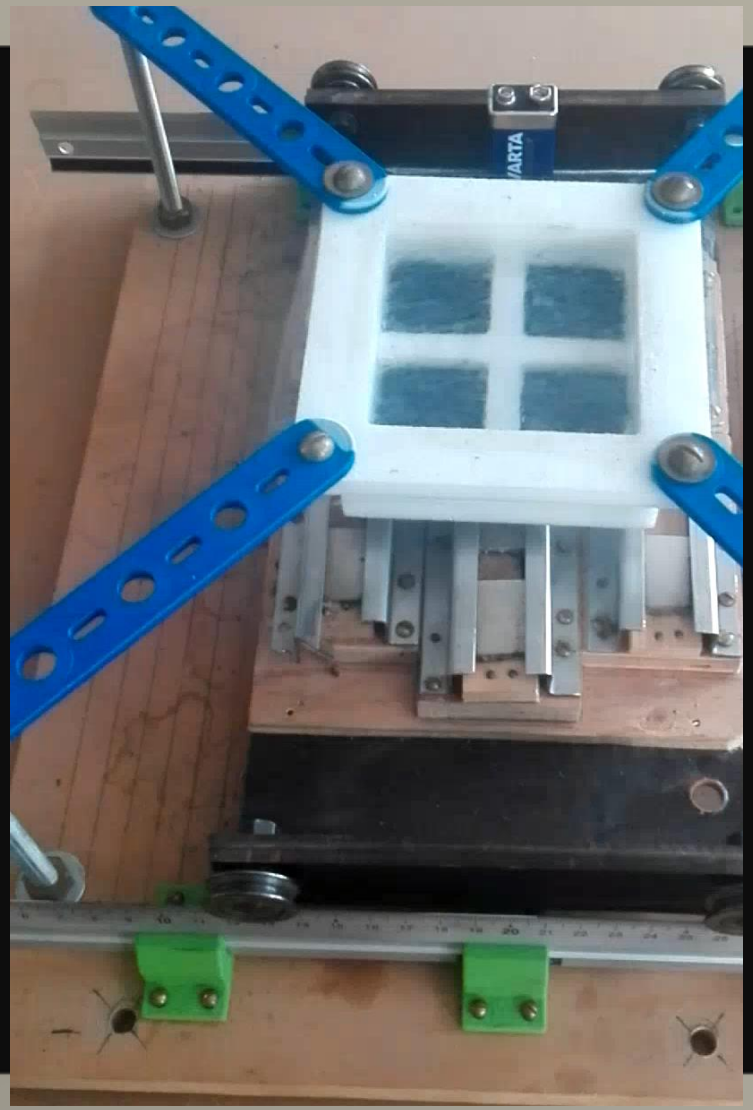
francisco.ferreira.silva@tecnico.ulisboa.pt; pbranco@tecnico.ulisboa.pt

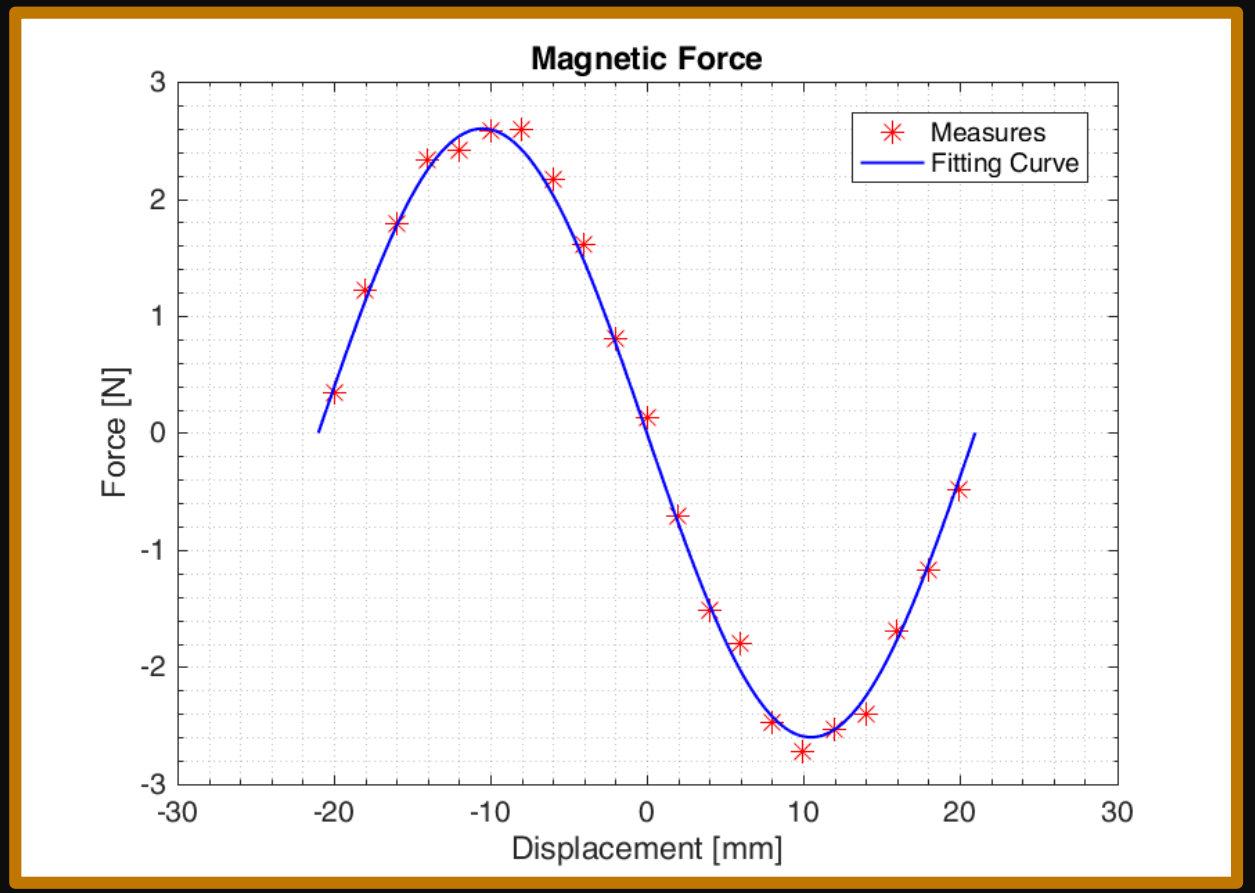
MOTIVATION

Rectangular ZFC-Maglev Prototype



Problem: Lateral Stability





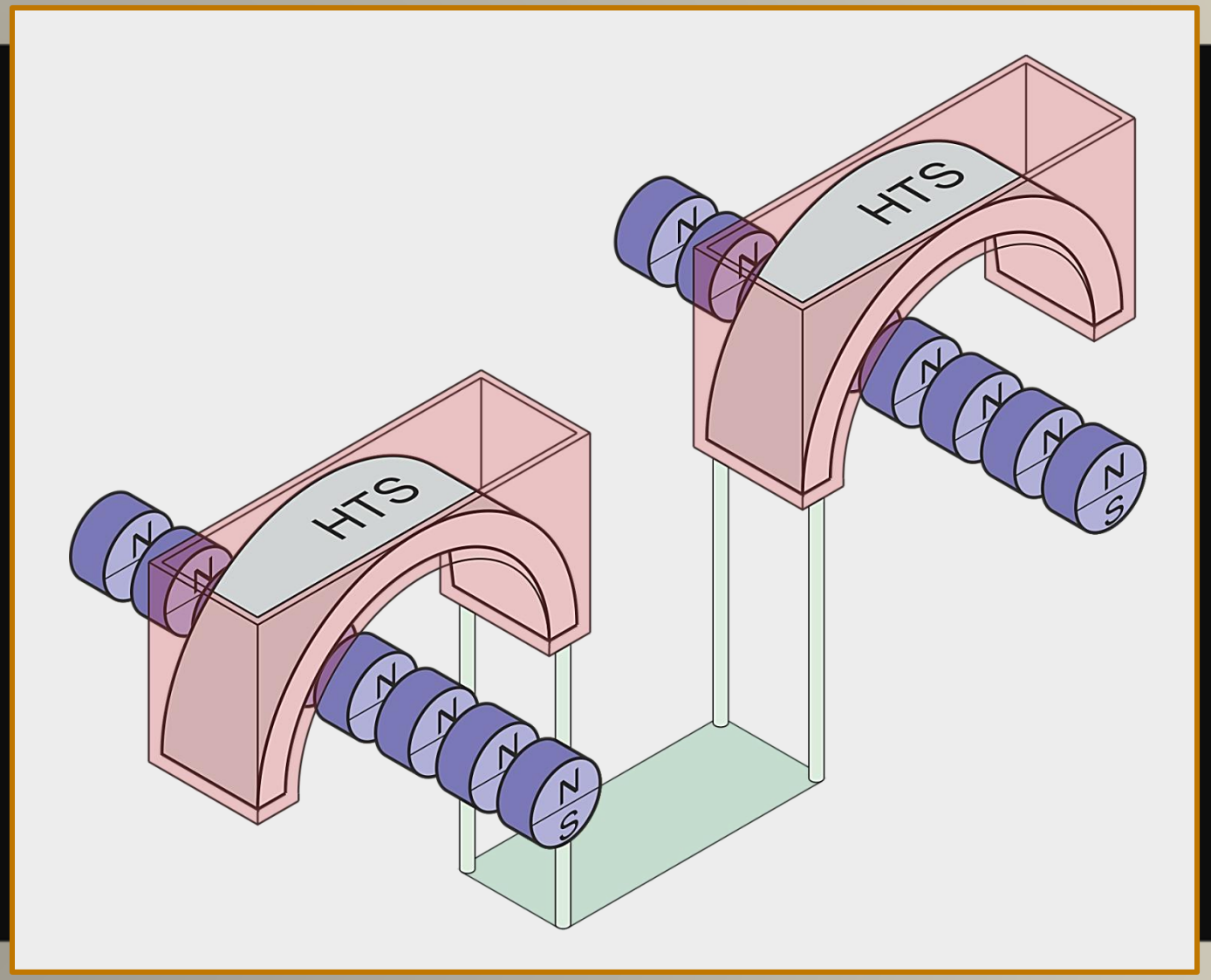
Lateral forces vs. lateral displacement

Possible Solution: Change the Geometry?

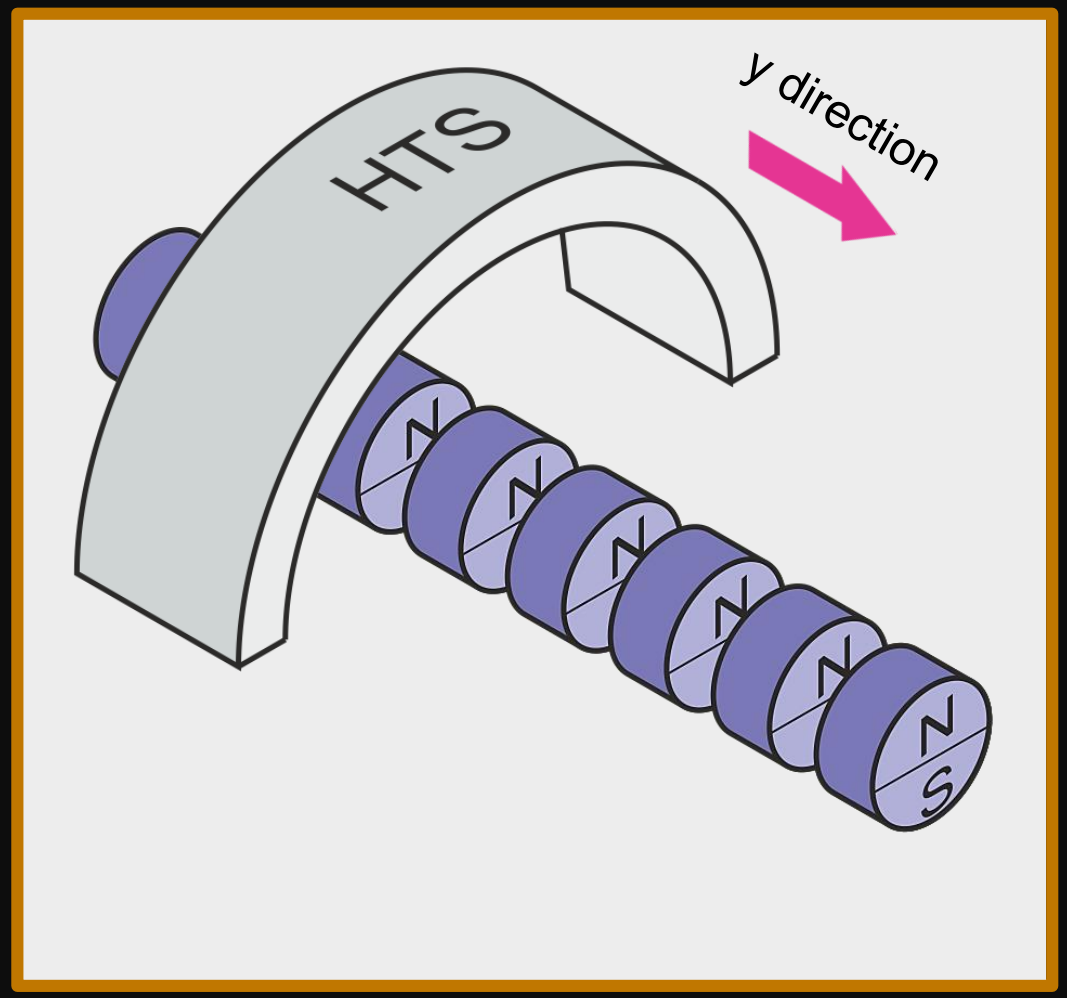
What if it is used a cylindrical geometry?

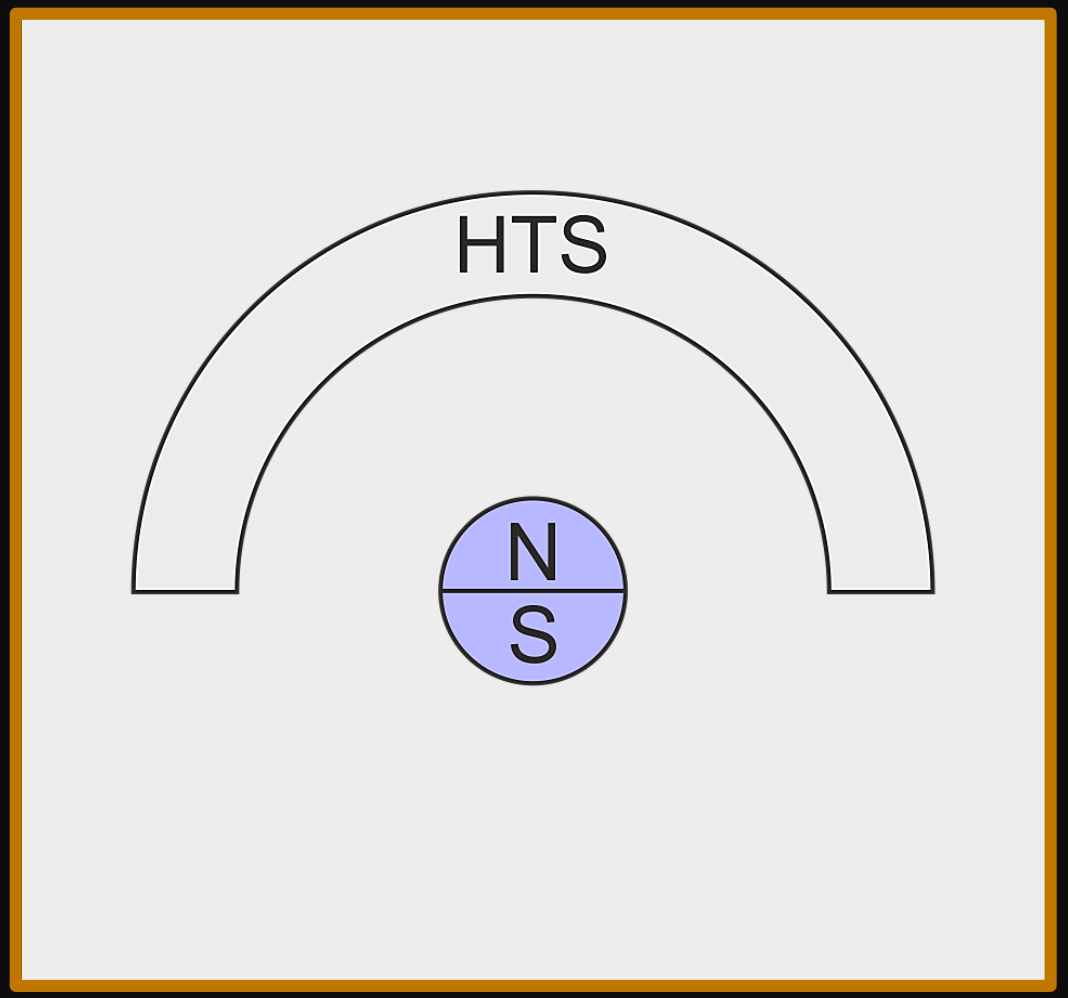
CONCEPT OF THE NEW CYLINDRICAL ZFC-MAGLEV

Design Concept

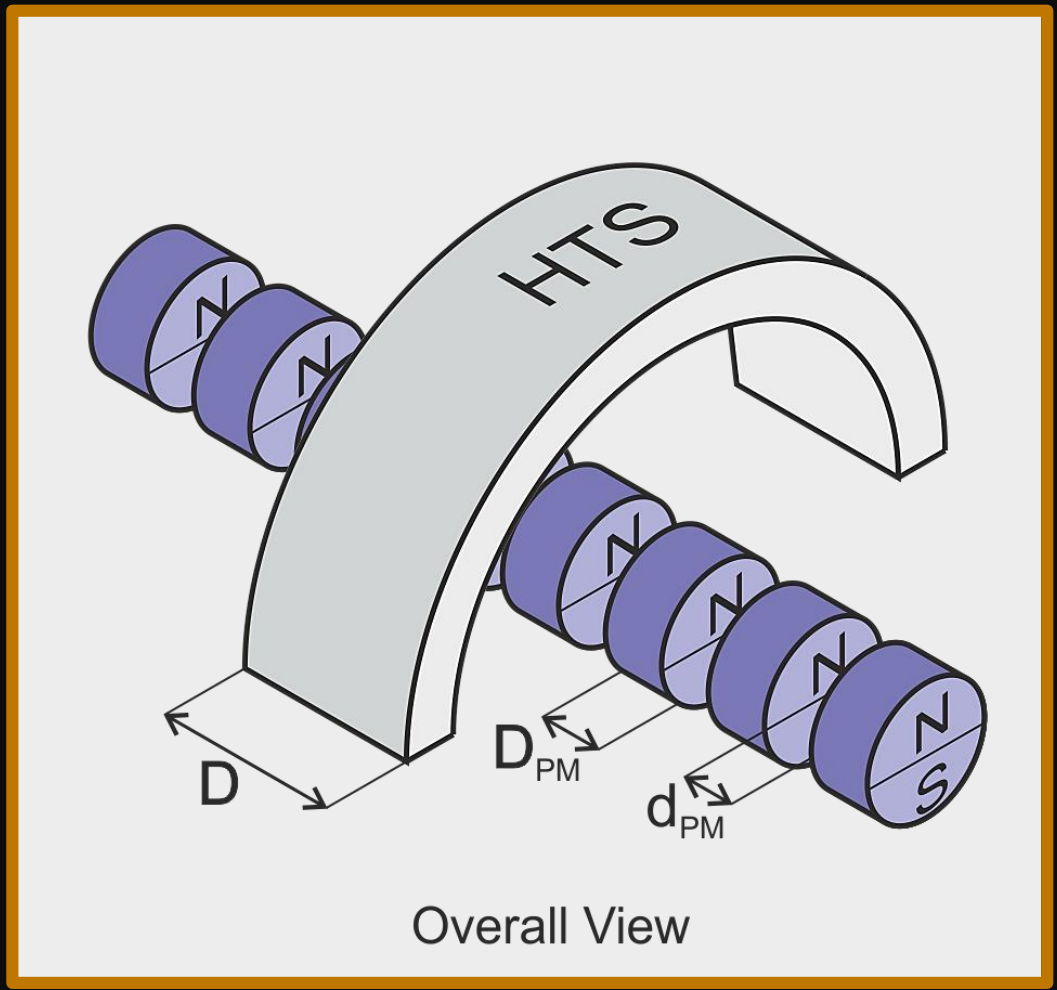


Magnetic Rail

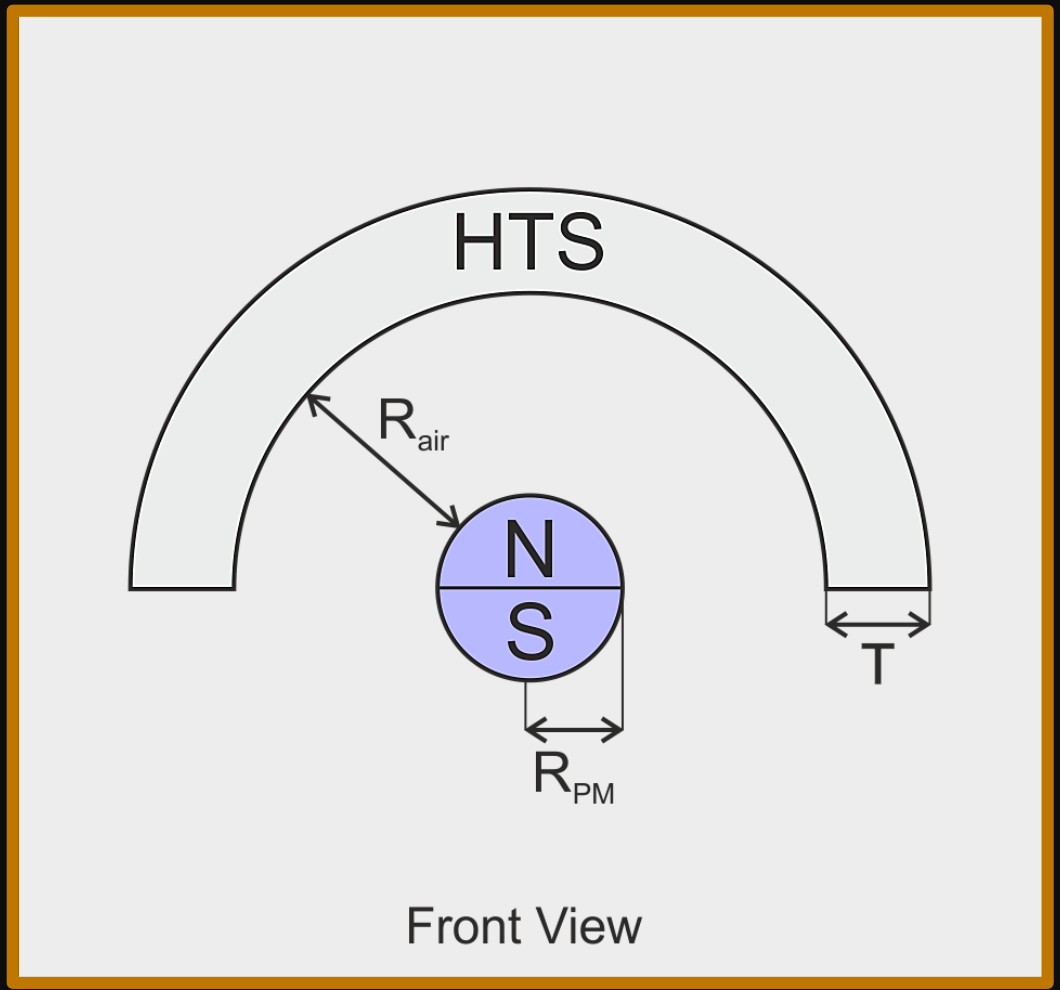




Geometric Description

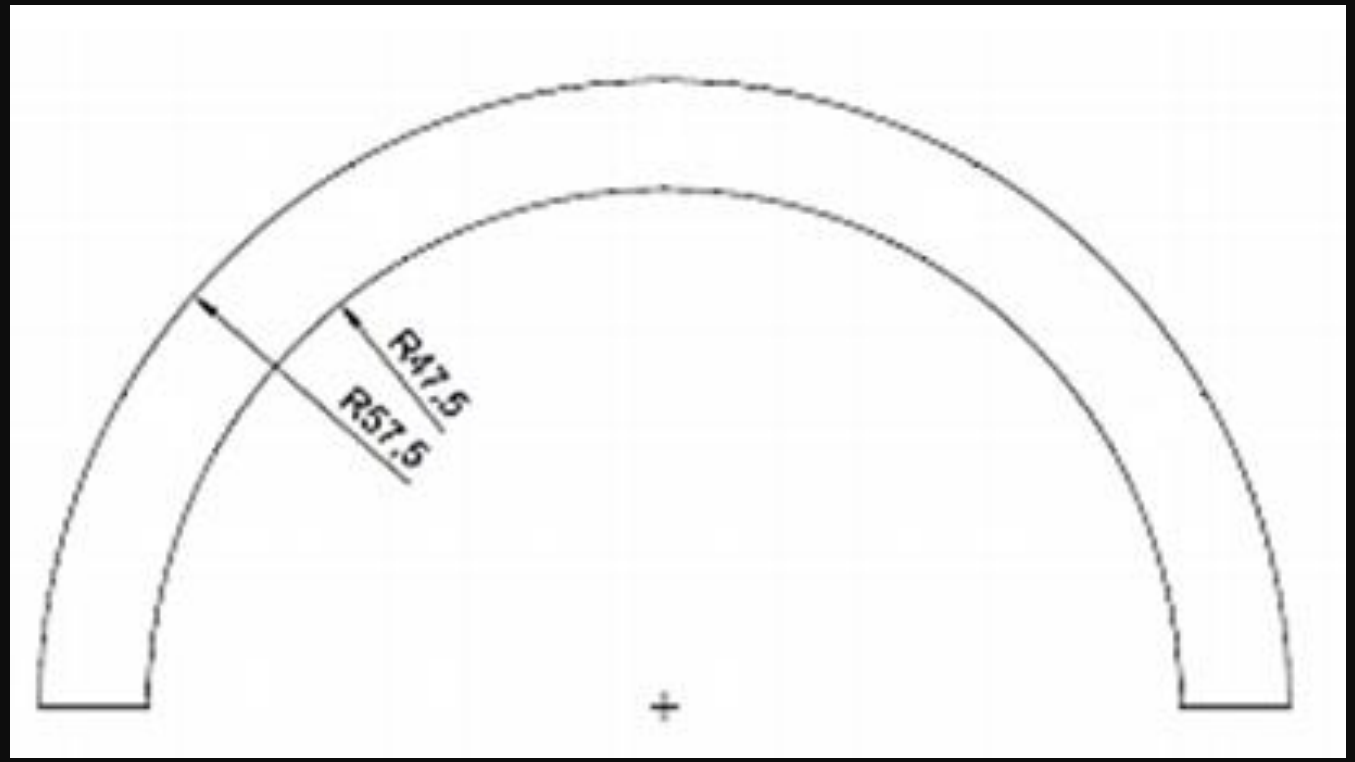


Overall View



Front View

Manufacturing Constraints



Total price Option B.1 (CIP Lisboa): € 9,760

Too expensive to create a prototype! Detailed Simulations, first!

SIMULATIONS OF THE CYLINDRICAL GEOMETRY

Finite Element Analysis using COMSOL Multiphysics

- Magnetic Field Formulation is used with E-J Power Law:

$$\mathbf{E} = E_0 \left(\frac{J}{J_C} \right)^n \frac{\mathbf{J}}{J}$$

$$J_C = \frac{B_0}{B_0 + B} J_{C0}$$

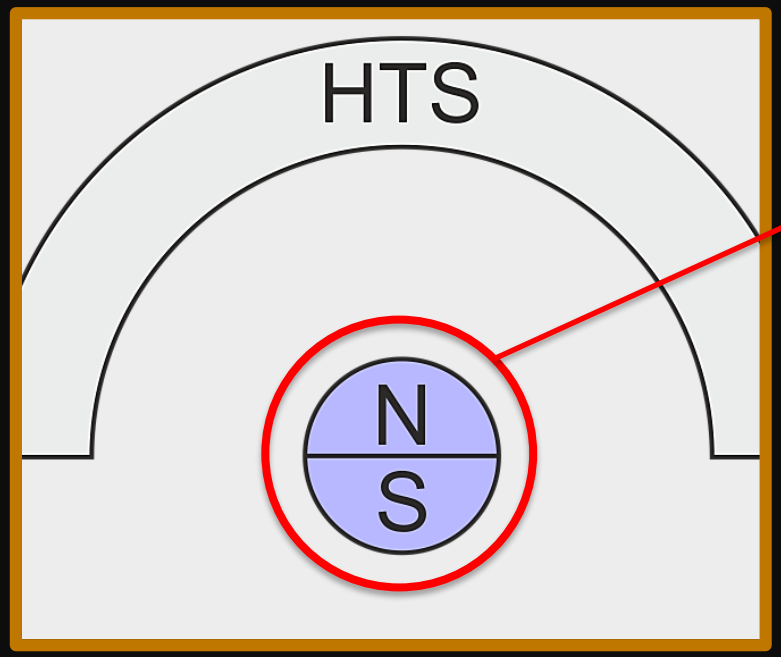
Values used for YBCO Bulks*

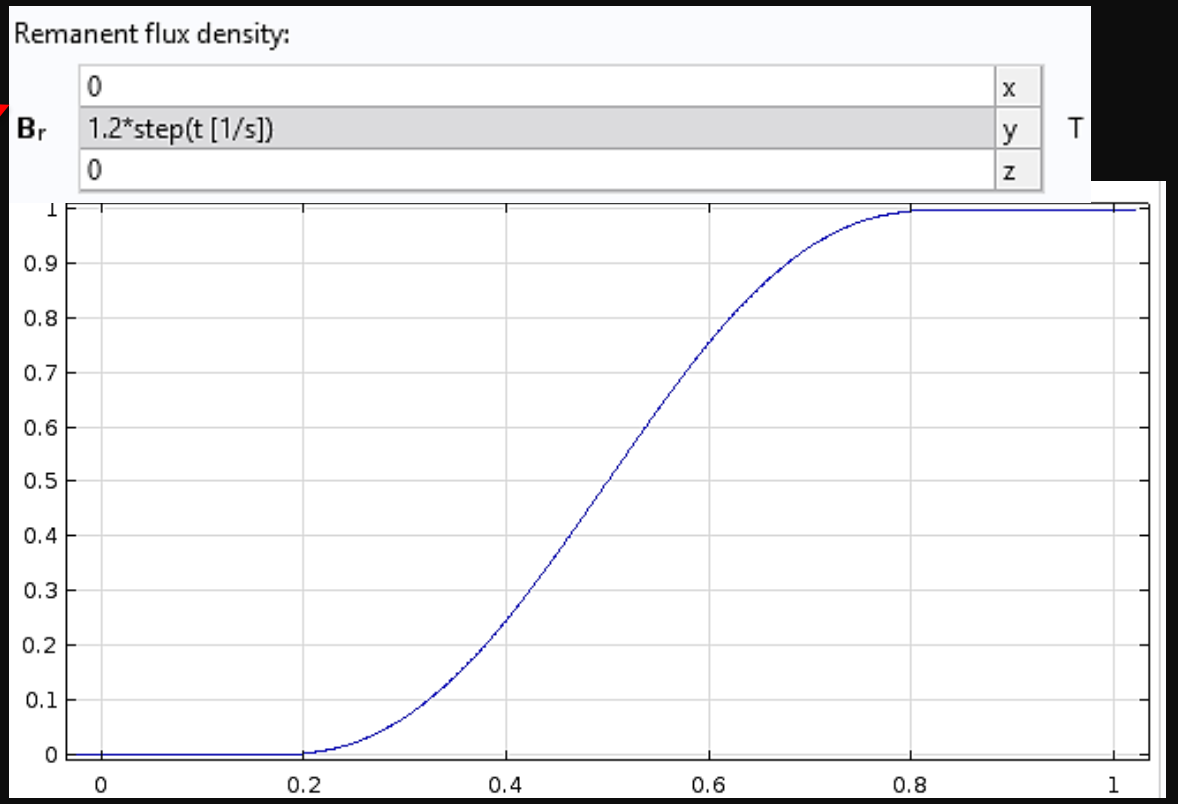
Variables	Values
E_0	$1 \cdot 10^{-4}$ $\mathrm{Vm^{-1}}$
n	30
B_0	0.1 T
J_{C0}	$1.82 \cdot 10^{8}$ $\mathrm{Am^{-2}}$

H. Serieiro. *Utilização de materiais supercondutores no circuito magnético de geradores eléctricos adaptados a fontes de energia renováveis.* Master's thesis, Instituto Superior Técnico, Universidade de Lisboa, 2015. Master's Advisors: J. Fernandes, P.J. da Costa Branco

Finite Element Analysis using COMSOL Multiphysics

- Time dependent study:

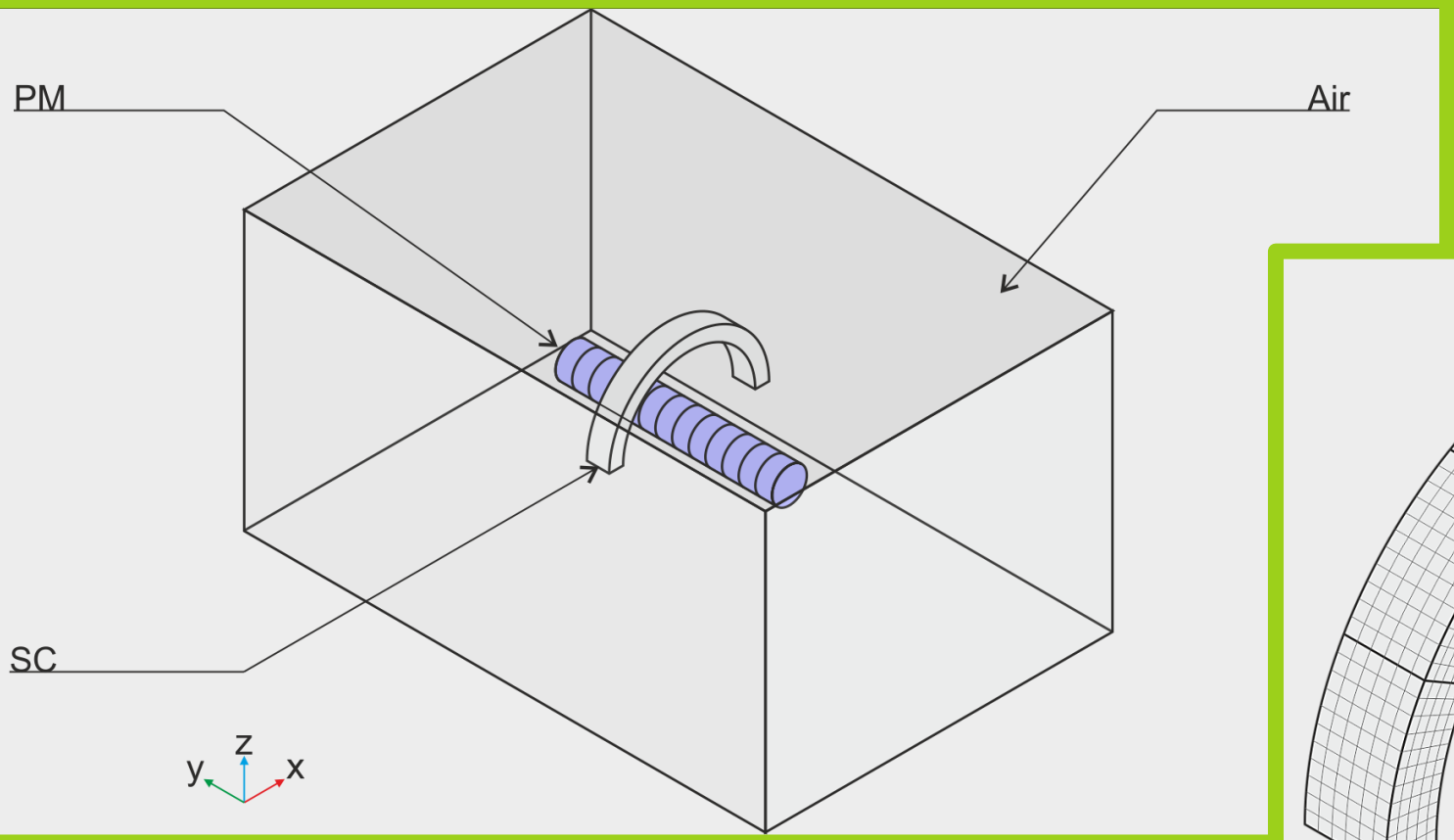


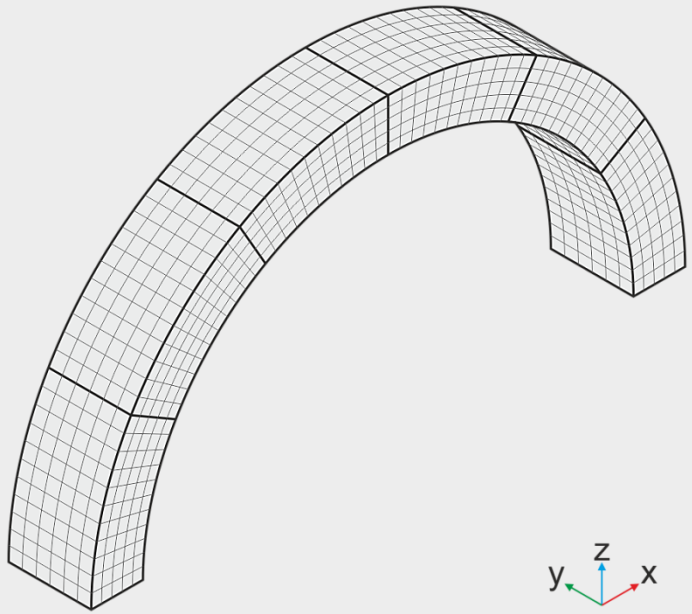


Step function

3D Simulations

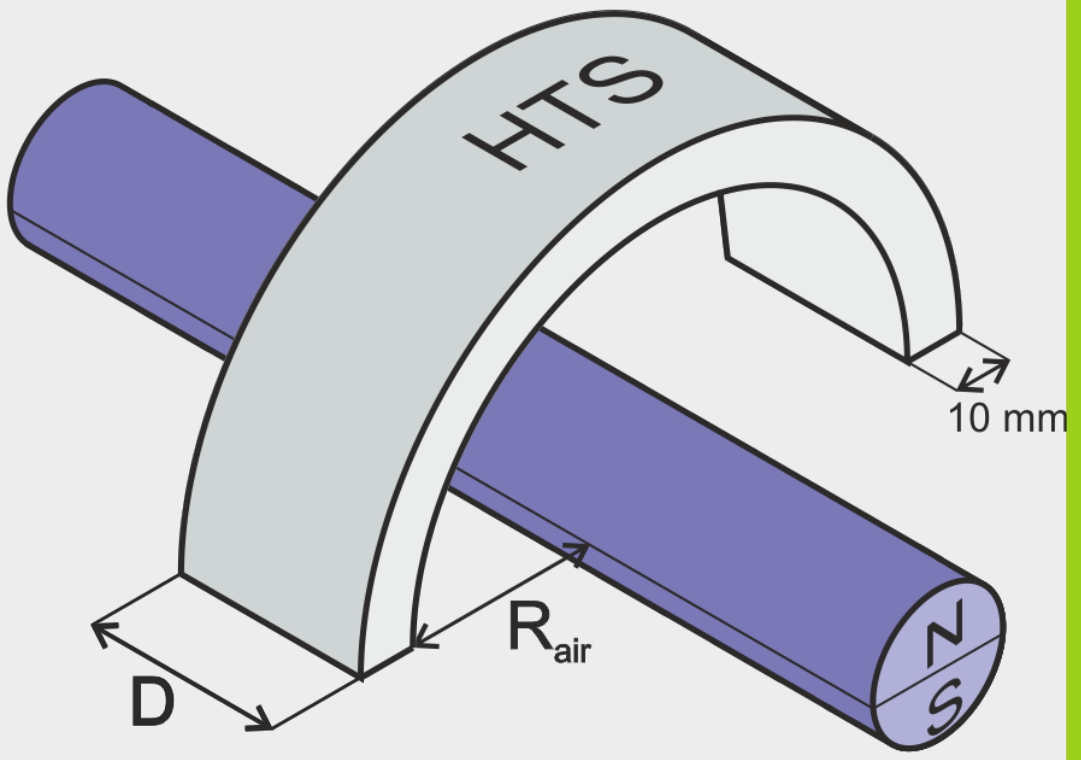
Geometry and Mesh Configuration





3D Simulations

Continuous PM Rail



Study 1

Parametric Sweep

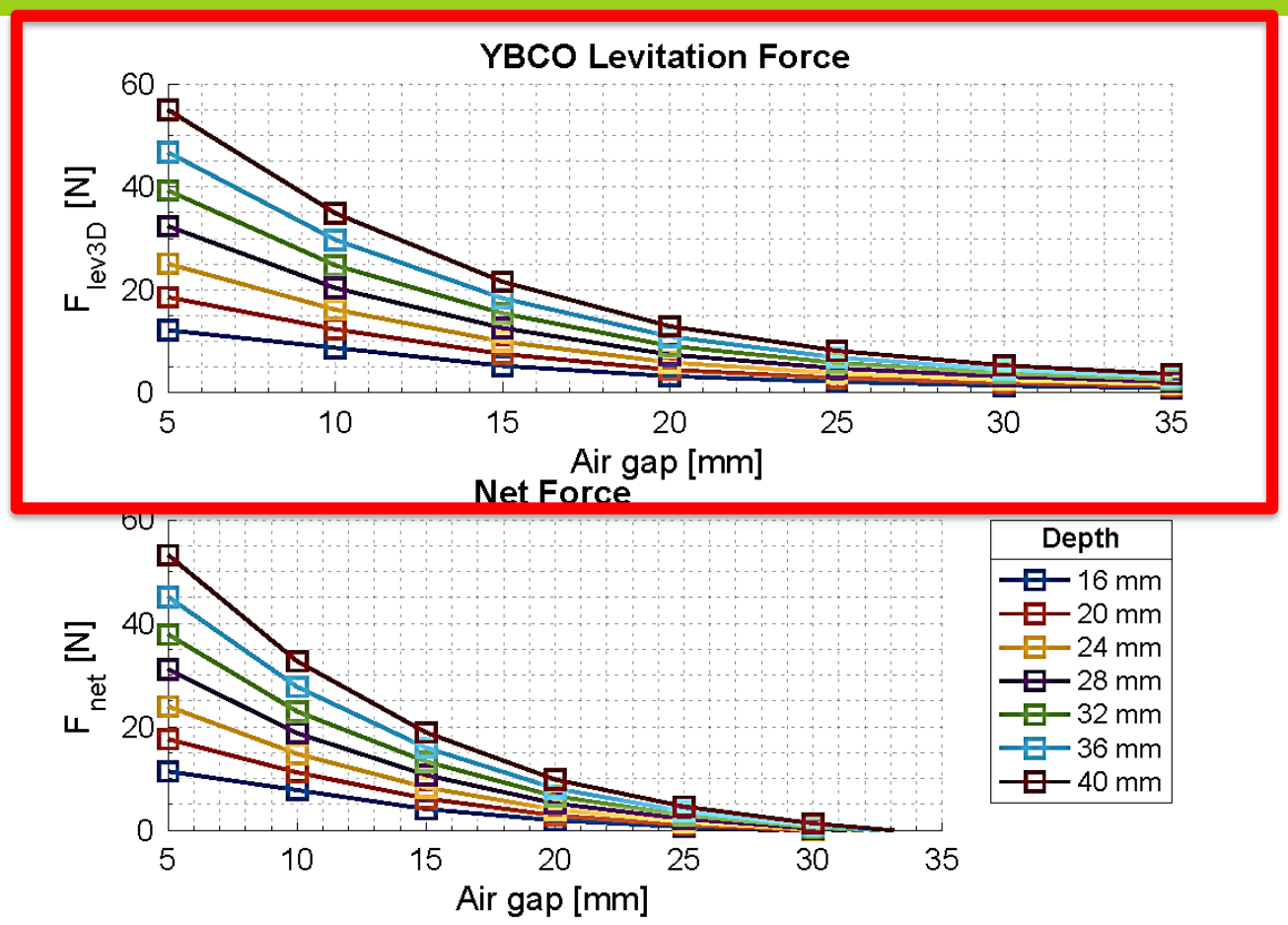
Step 1: Time Dependent

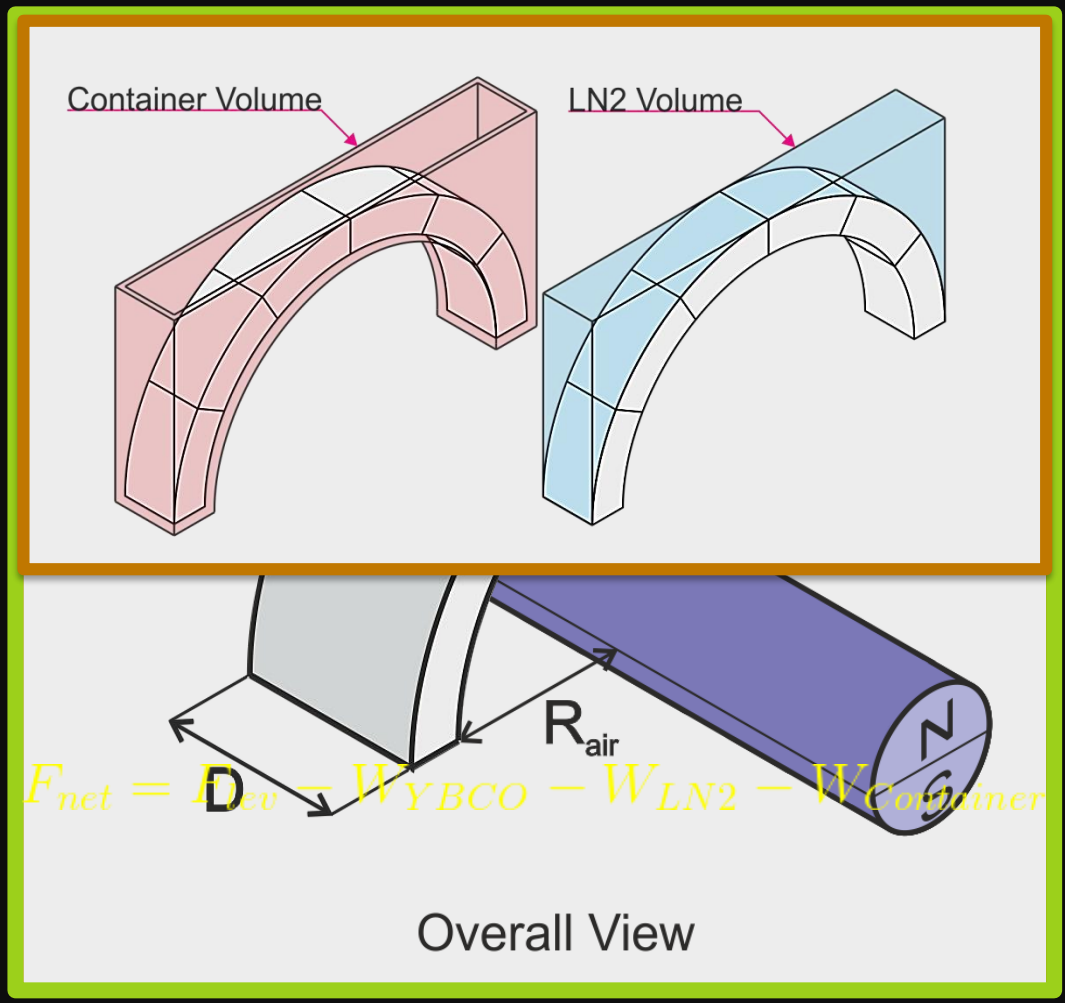
Sweep type: All combinations

Parameter nam	Parameter value list
Rair	range(5,5,30)
D	range(16,4,40)

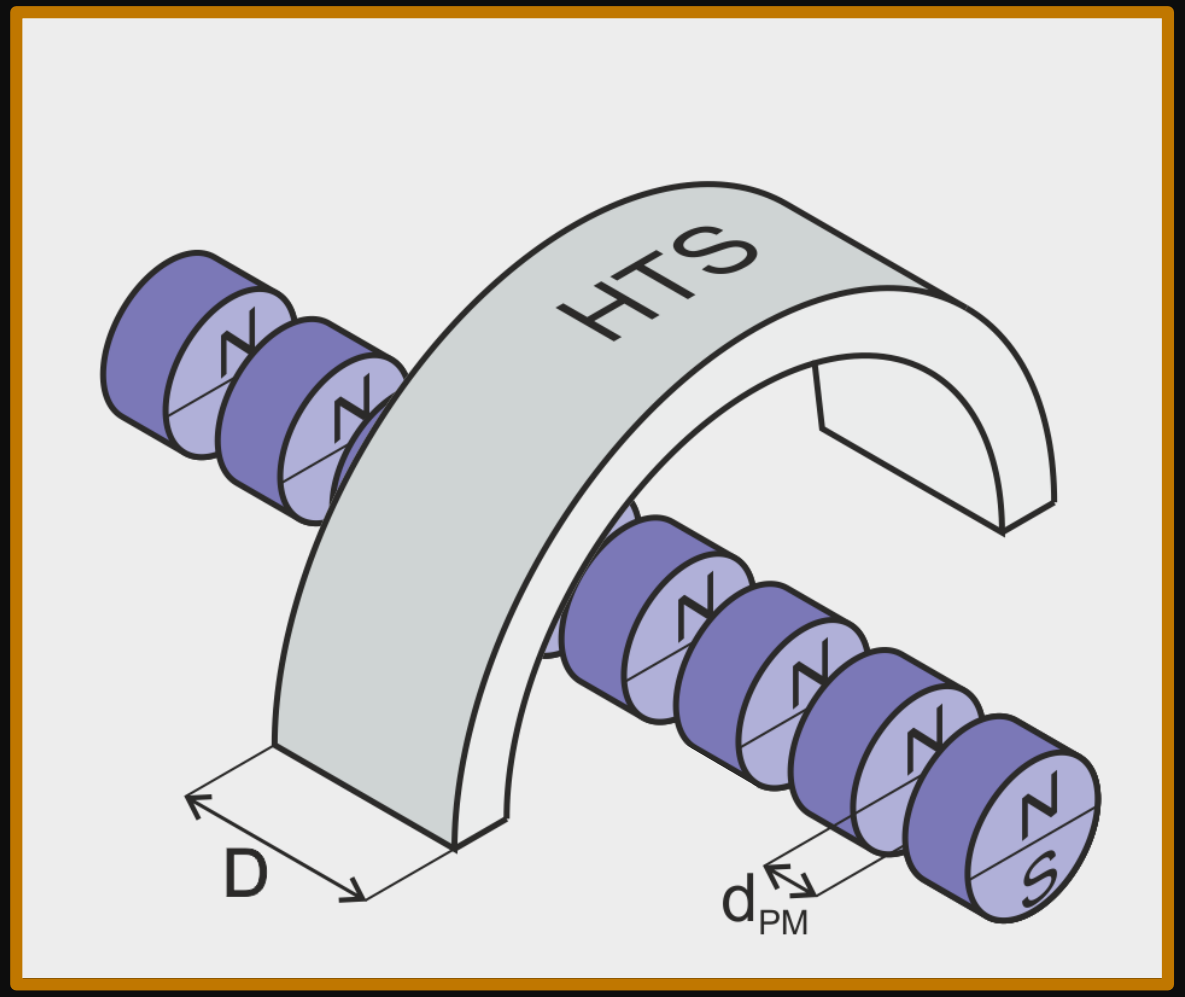
Continuous PM Rail

Results





3D Simulations
Discrete PM Rail



Study 1

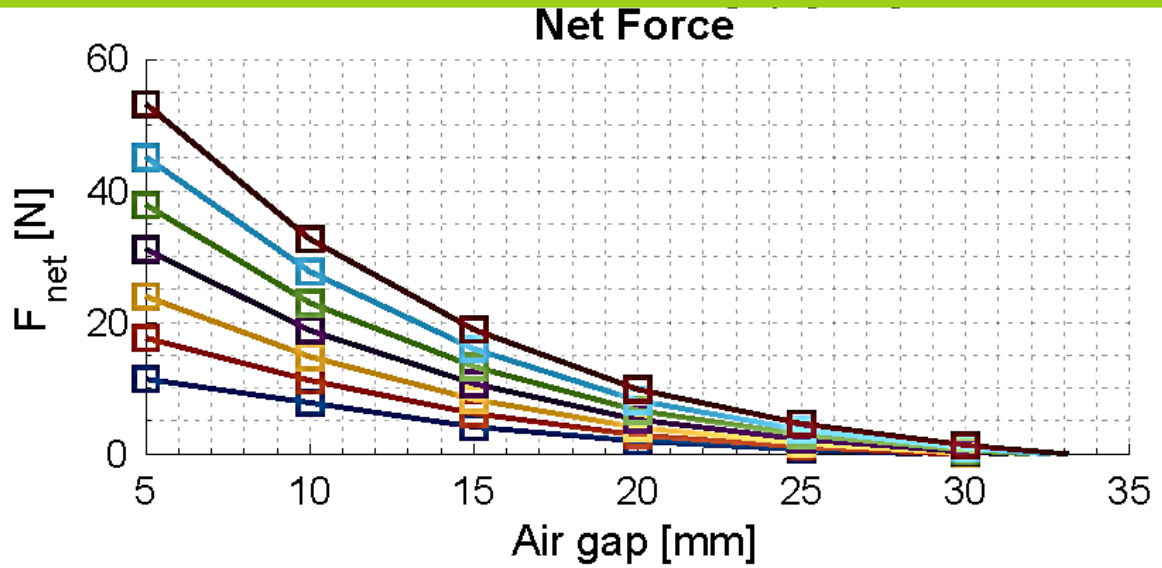
Parametric Sweep

Step 1: Time Dependent

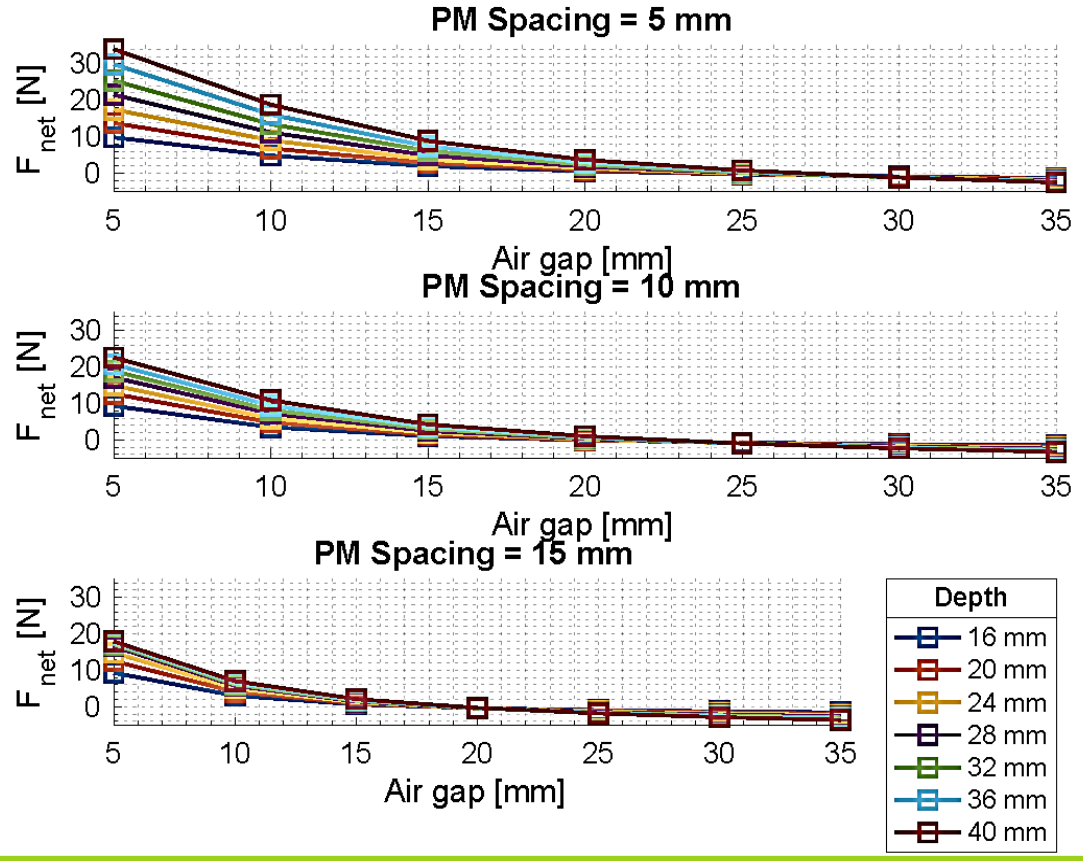
Sweep type: All combinations

Parameter nam	Parameter value list
Rair	range(5,5,30)
D	range(16,4,40)
d_PM	5,10,15

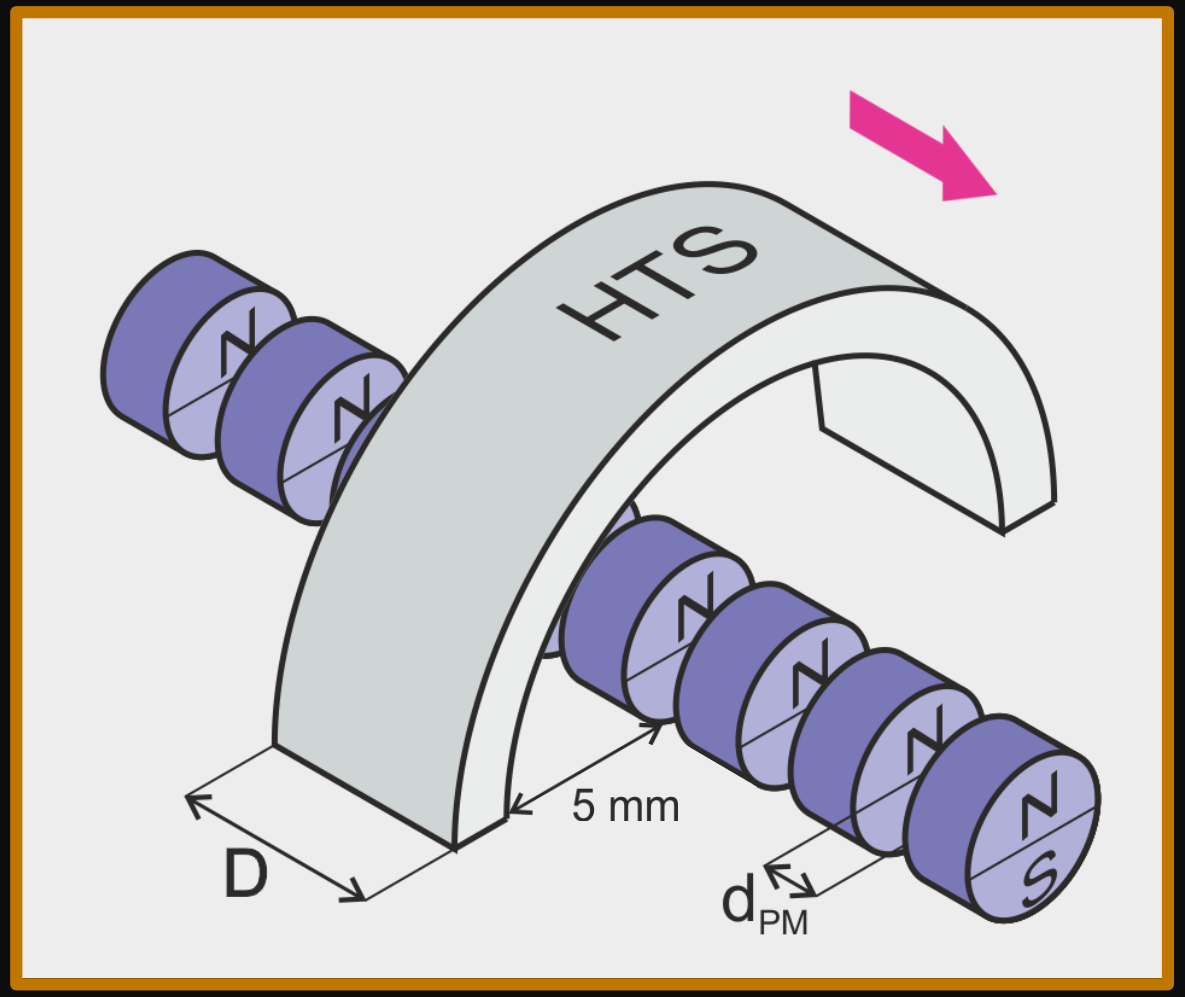
Discrete PM Rail Results



PM Spacing = 0 mm



3D Simulations
Moving Along the Rail

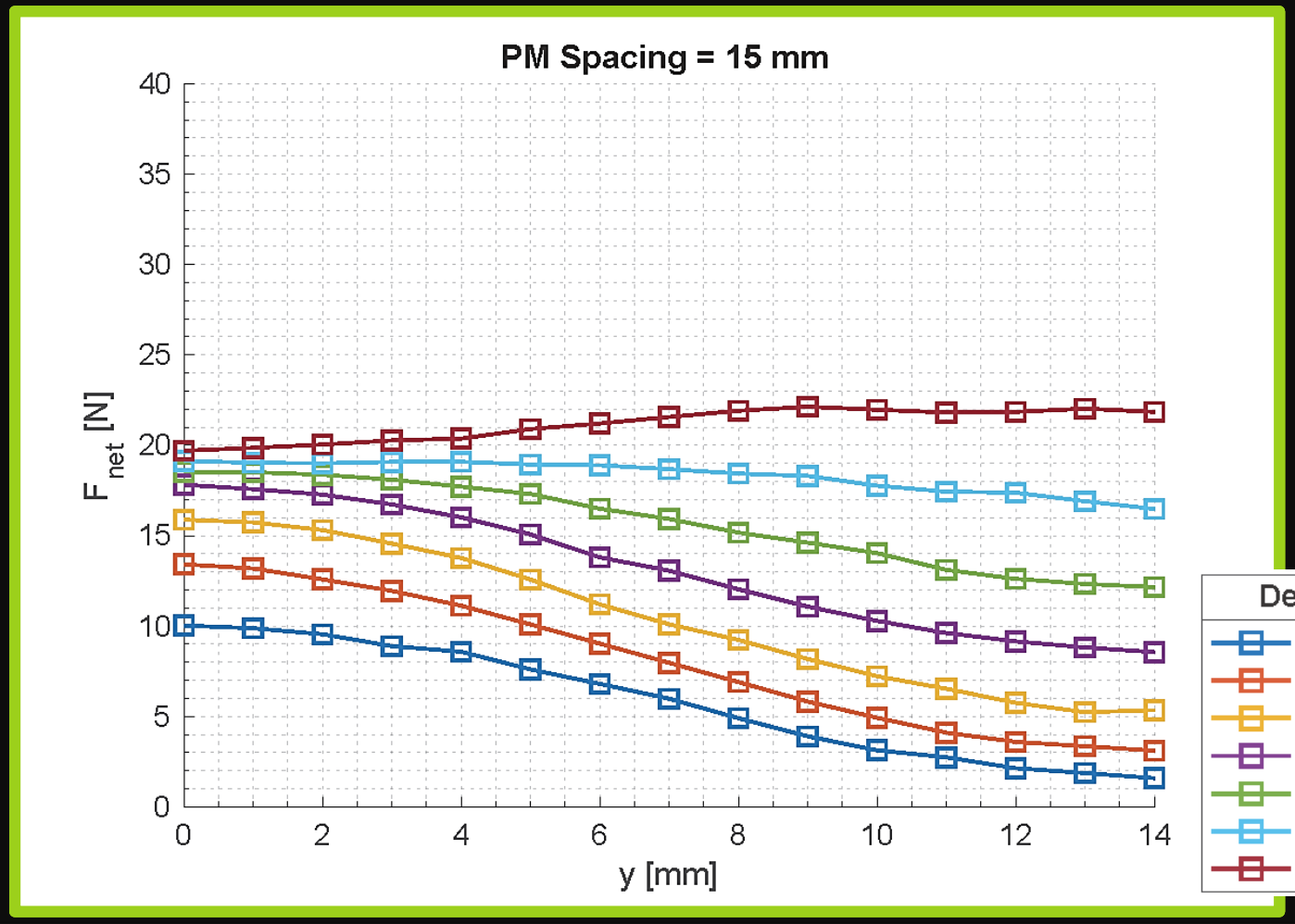


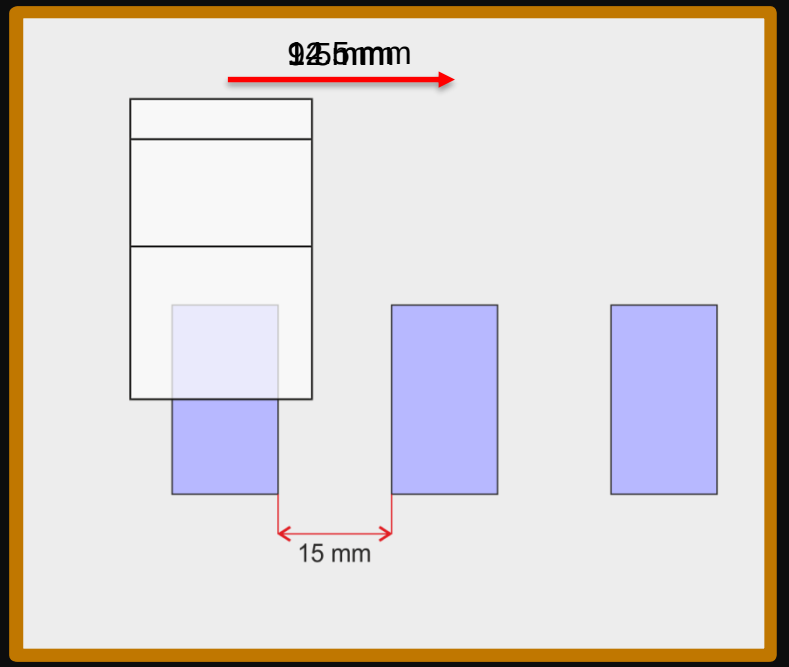
Study 1
Parametric Sweep
Step 1: Time Dependent

Sweep type: All combinations

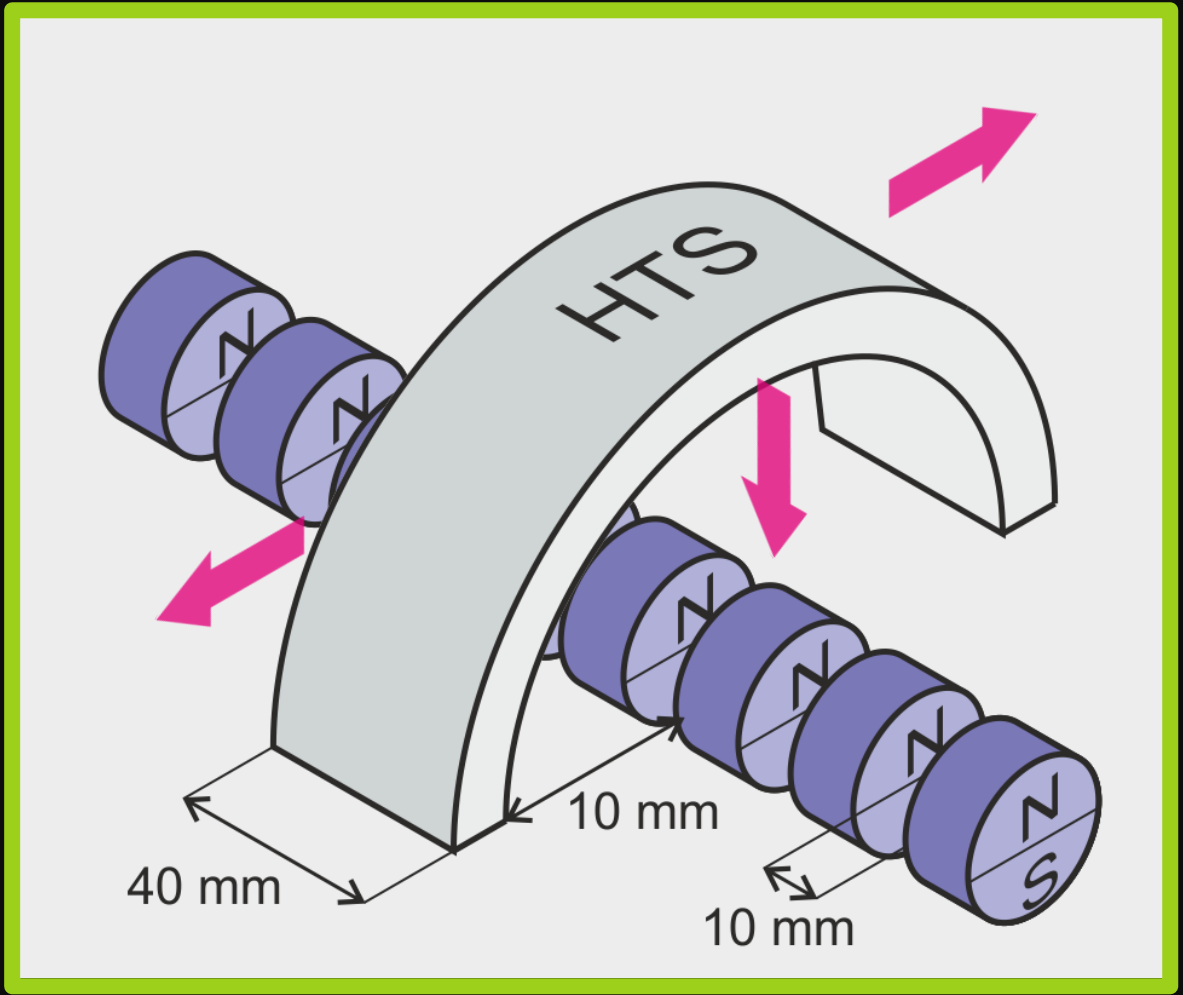
Parameter nam	Parameter value list
Rair	5
D	range(16,4,40)
d_PM	5,10,15
y_move	range(0,1,19)

Moving Along the Rail Results





3D Simulations
Lateral and Downward Movement

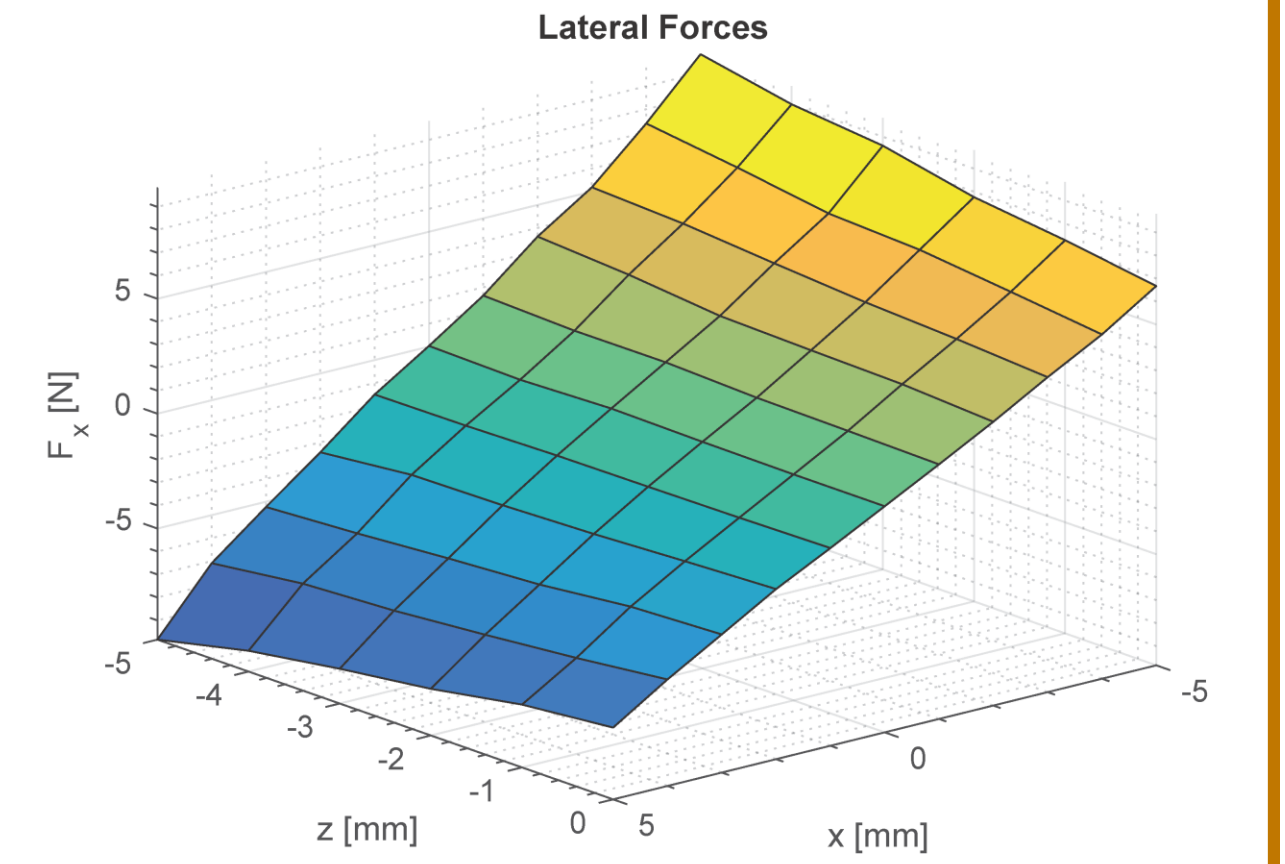


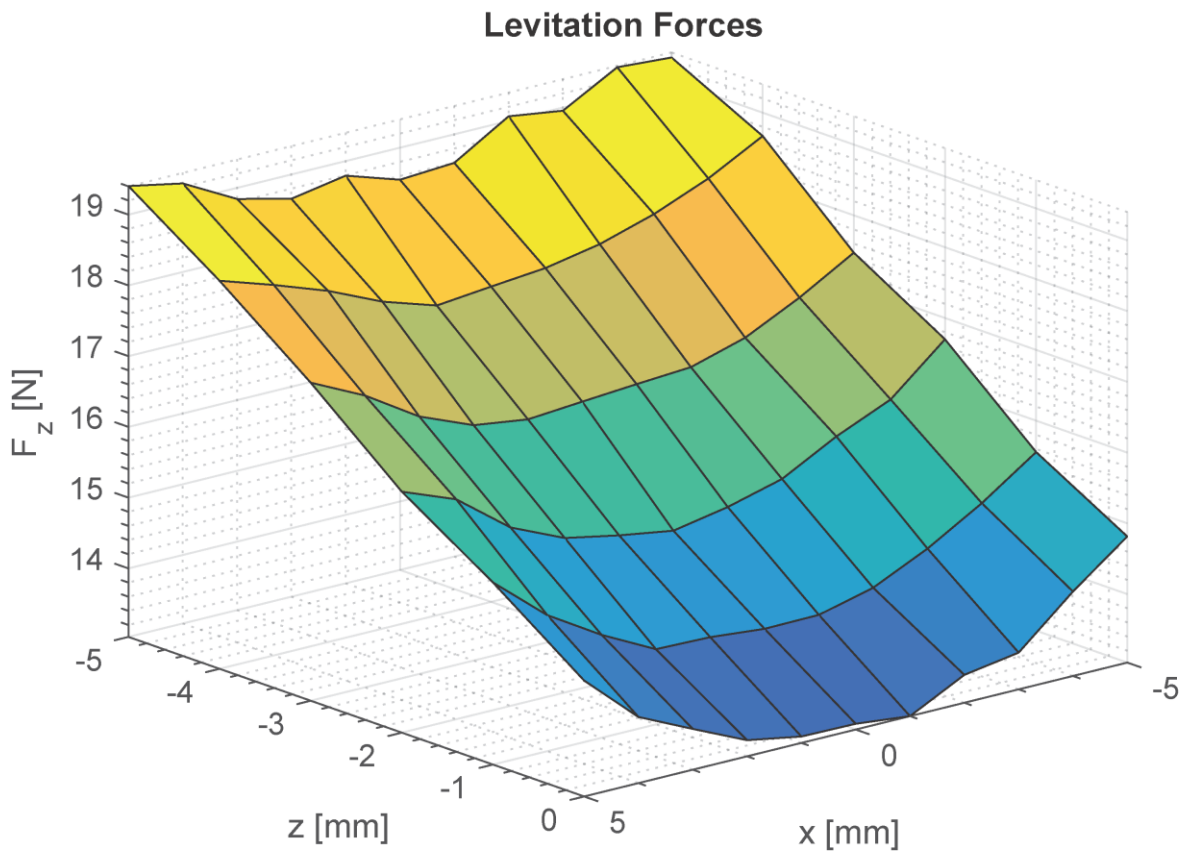
Study 1
Parametric Sweep
Step 1: Time Dependent

Sweep type: All combinations

Parameter nam	Parameter value list
x_move	range(-5,0,5)
z_move	range(0,-1,5)

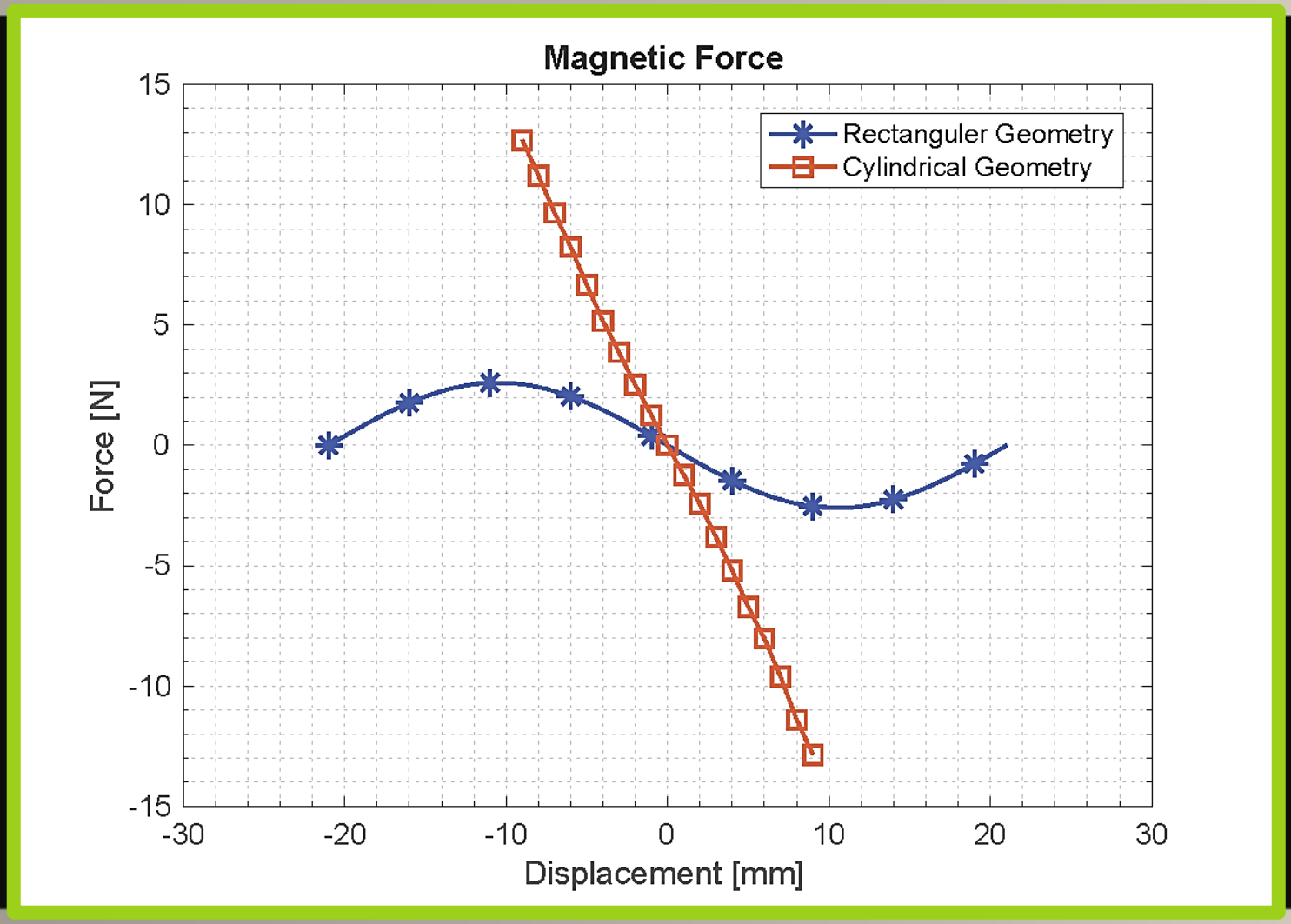
Lateral and Downward Movement Results





LATERAL FORCE COMPARISON

Lateral Force Comparison



CONCLUSIONS

Conclusions

- A study of a new cylindrical geometry were made, regarding the levitation and lateral forces;
- A comparison between the rectangular and cylindrical geometry is made regarding the lateral forces;
- There is a strong indication that the Cylindrical Geometry has better lateral stability than the Rectangular Geometry;

Future Work

- Make a study with a moving mesh to check the dynamics of the car while moving across the magnetic rail;
- Develop a prototype to validate the simulations;
- Check the influence of the flux pinning in the lateral dynamics;

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Thank you!