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AGH UNIVERSITY OF SCIENCE  
AND TECHNOLOGY

# Features and Limitations of 2D Active Magnetic Levitation Systems Modeling in COMSOL Multiphysics

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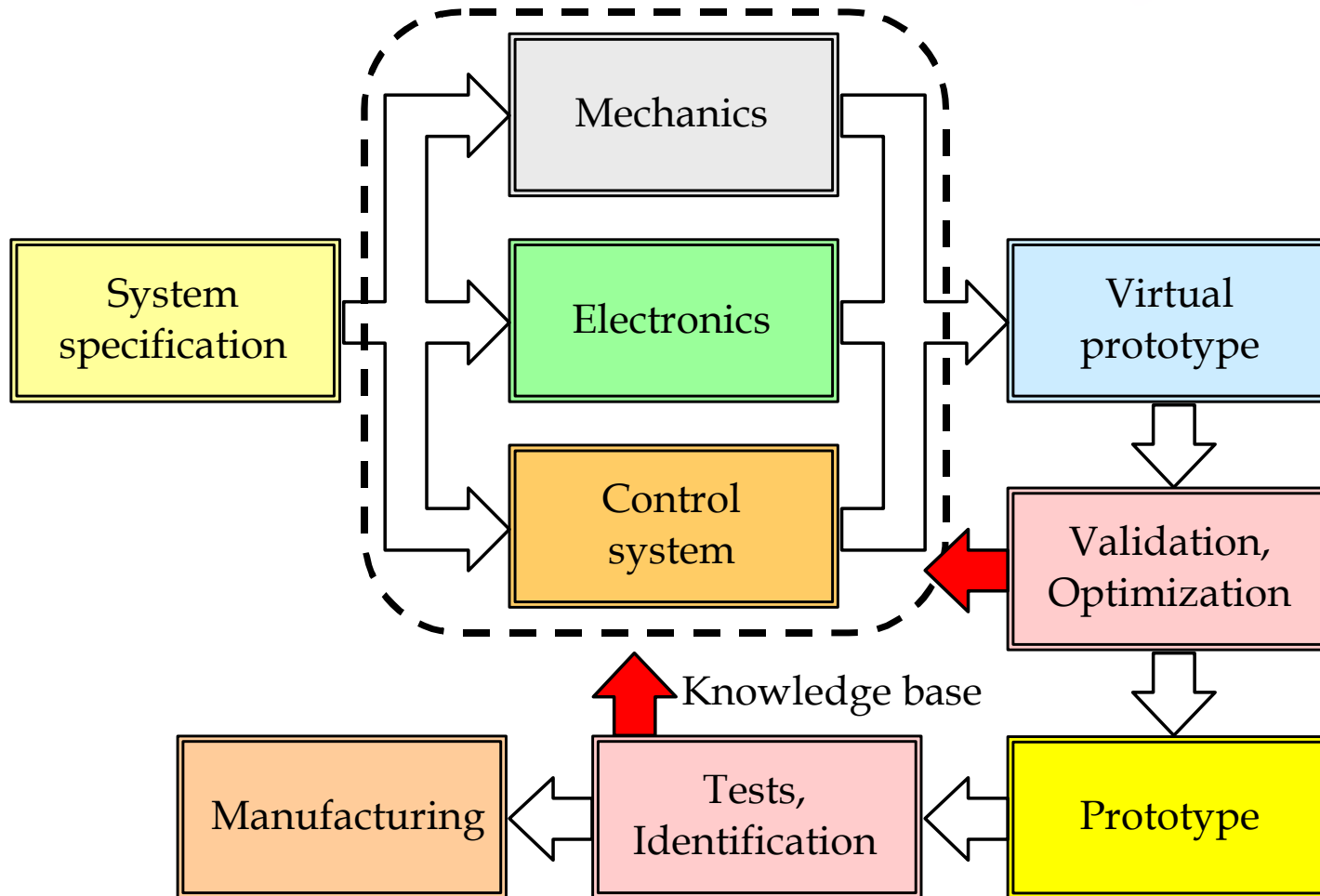
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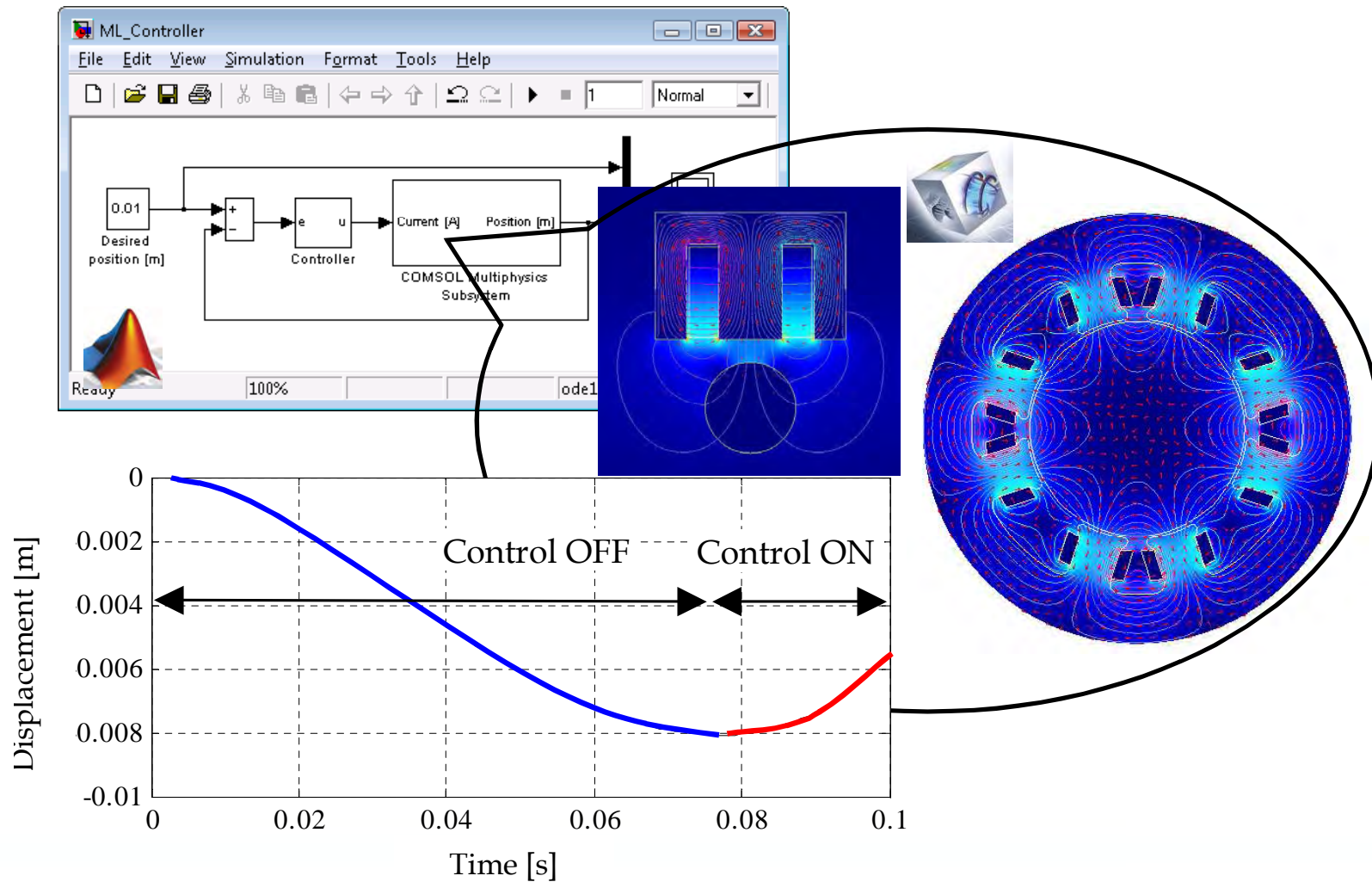
## **Agenda**

- **Interdisciplinary design**
- **Active Magnetic Suspension**
- **Active Magnetic Bearing**
- **Automata for modelling**
- **Optimisation**
- **PDE+ODE**
- **Conclusions**

# The proposed interdisciplinary Design Approach where virtual prototype is being developed and studied



# Interdisciplinary dynamics modelling and simulation

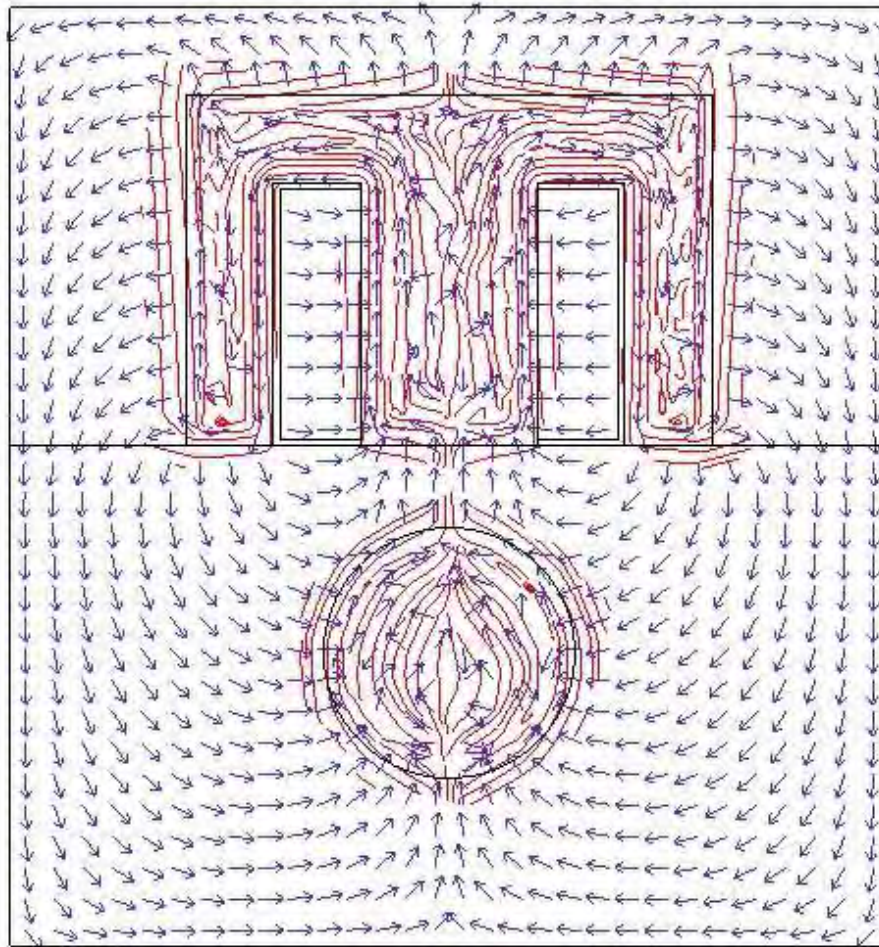




# Magnetic levitation system MLS1EM in action.



## Cross-section model of the MLS1EM

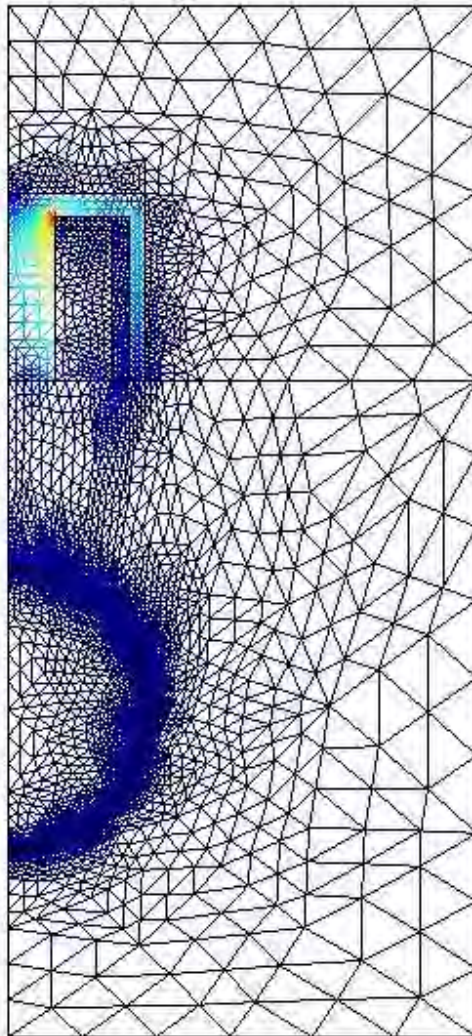


This figure presents the magnetization and magnetic field in the form of streamlines and arrows respectively. One can find that the levitated object is self centered with respect to the actuator geometry and the iron based components are magnetized.

# MLS2EM - upper electromagnet replaced with cylindrical one



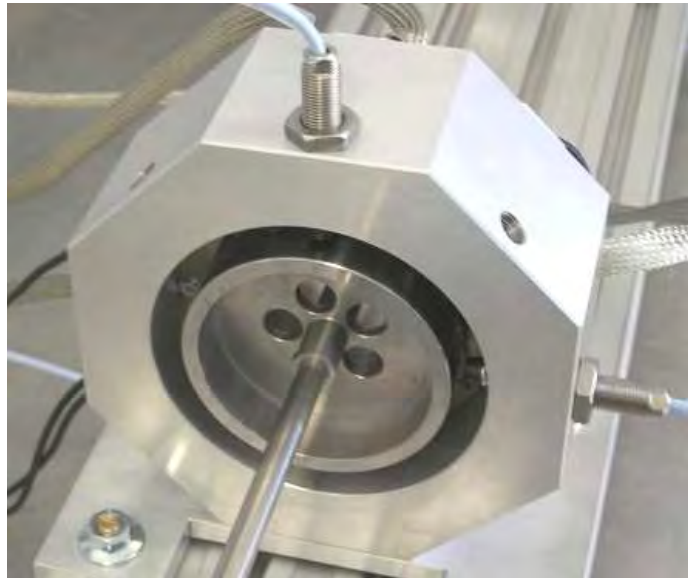
# Magnetic flux density represented in the wire frame mode.





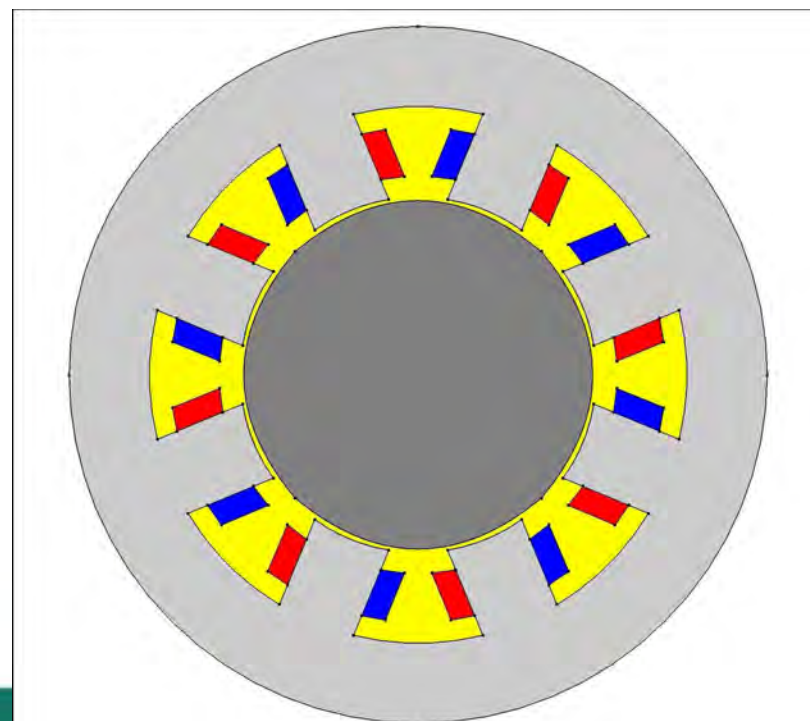
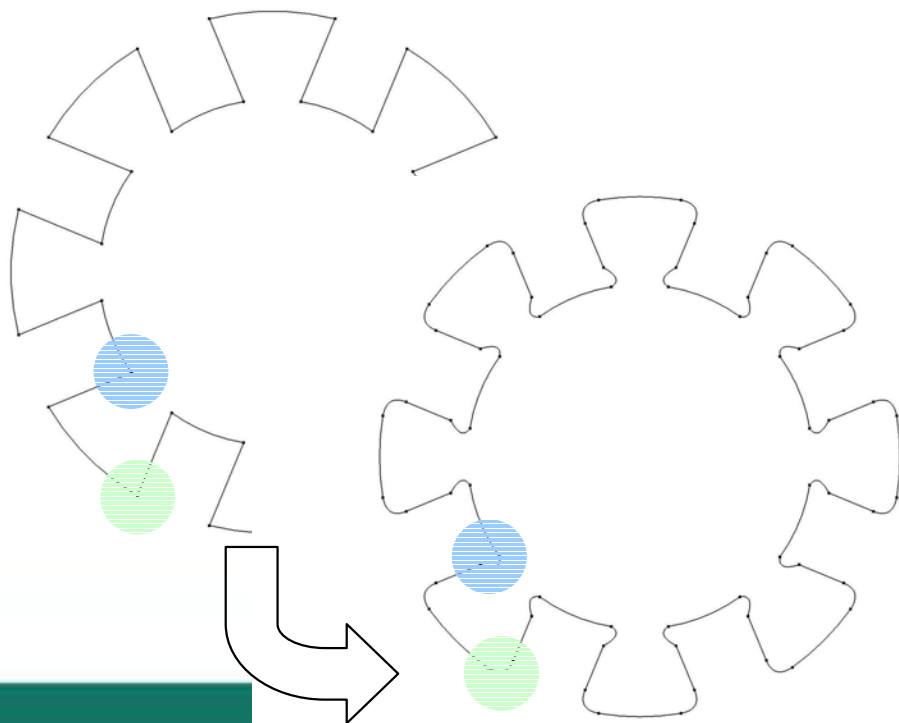
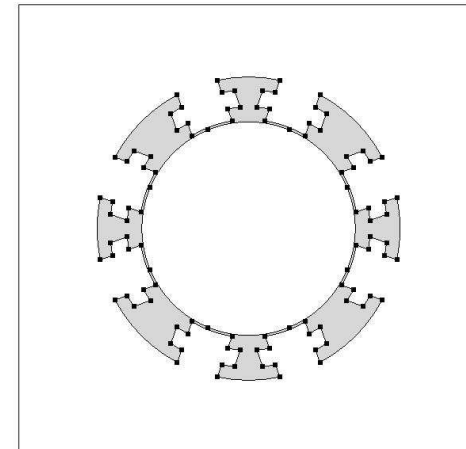
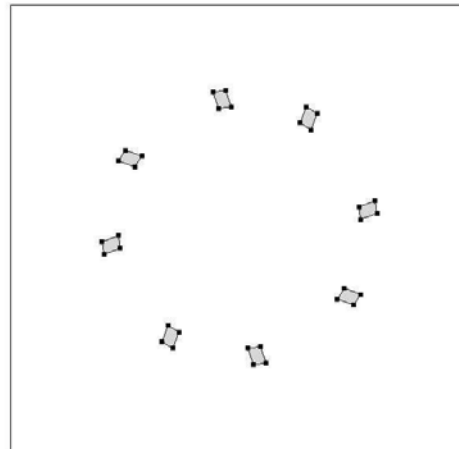
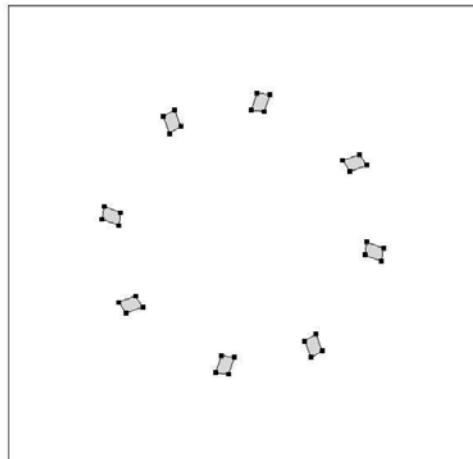
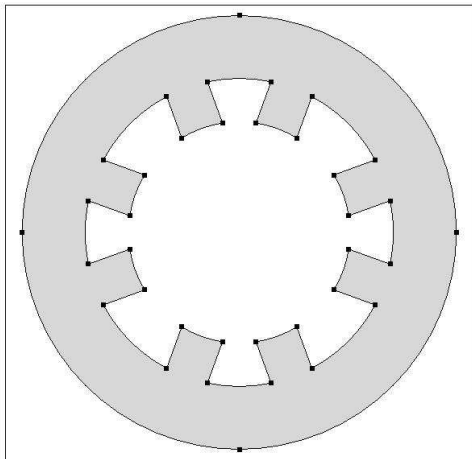


# Active Magnetic Bearing

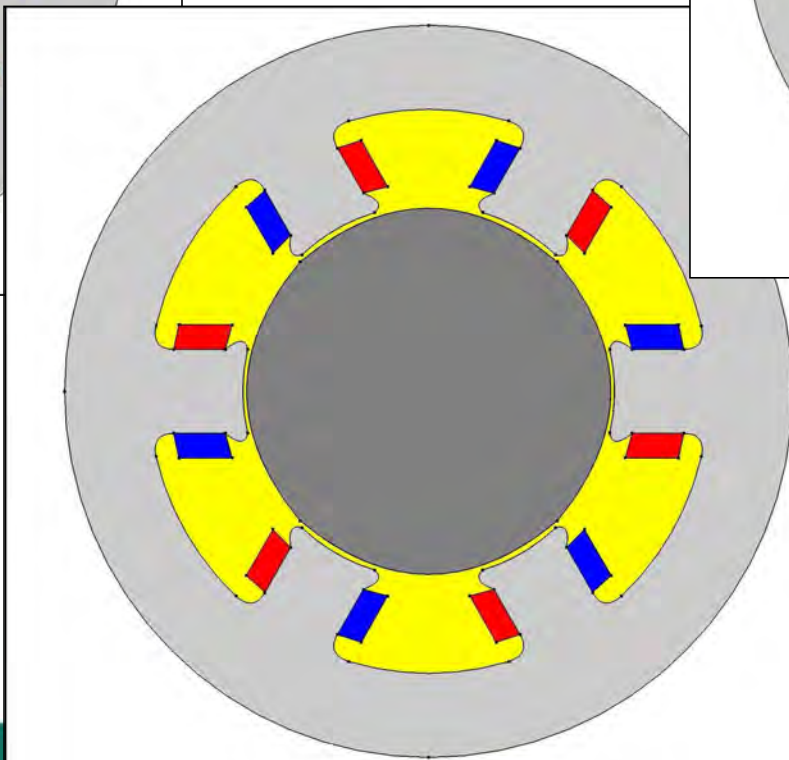
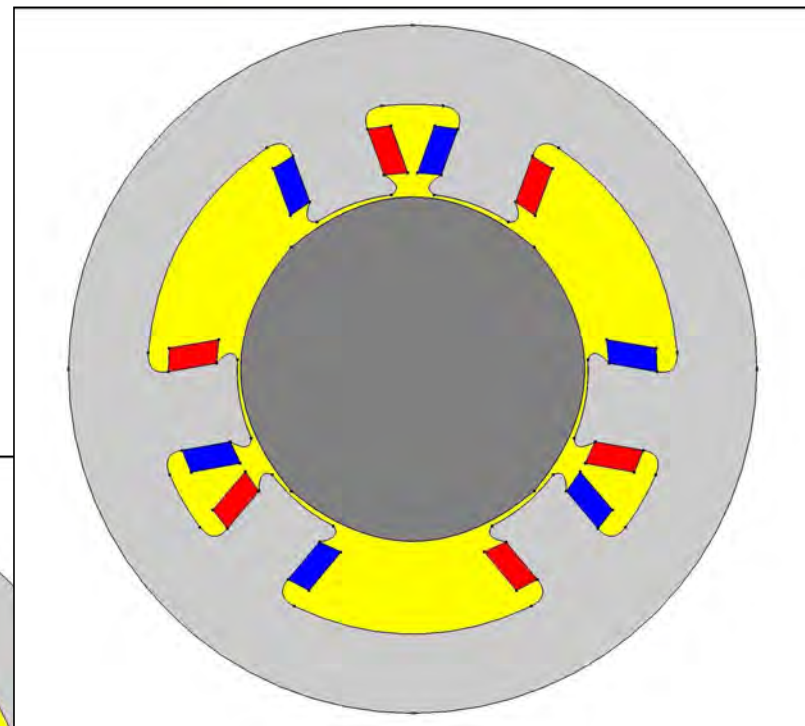
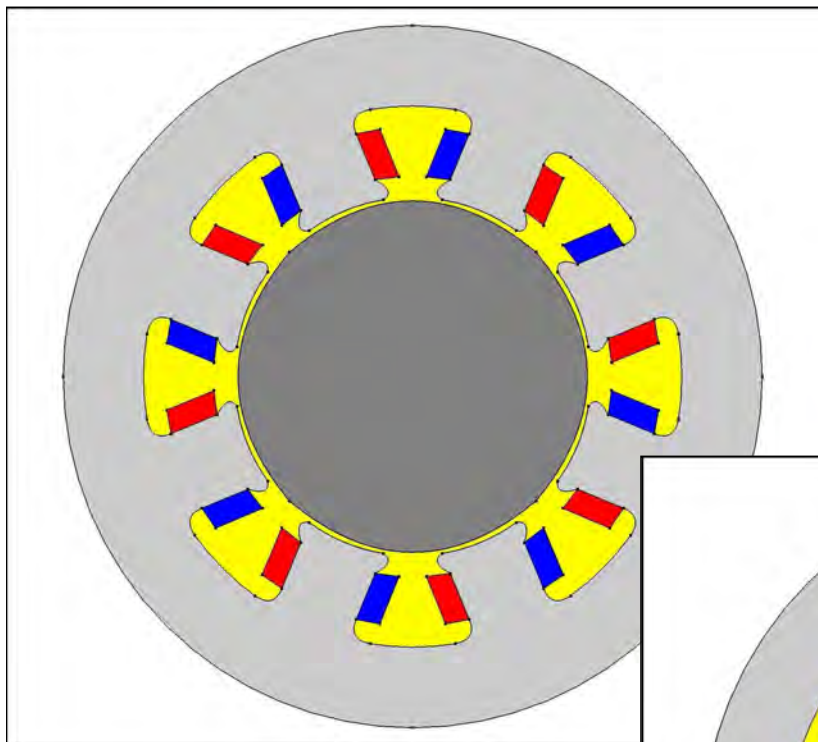




# Geometry generator



# Geometry generator

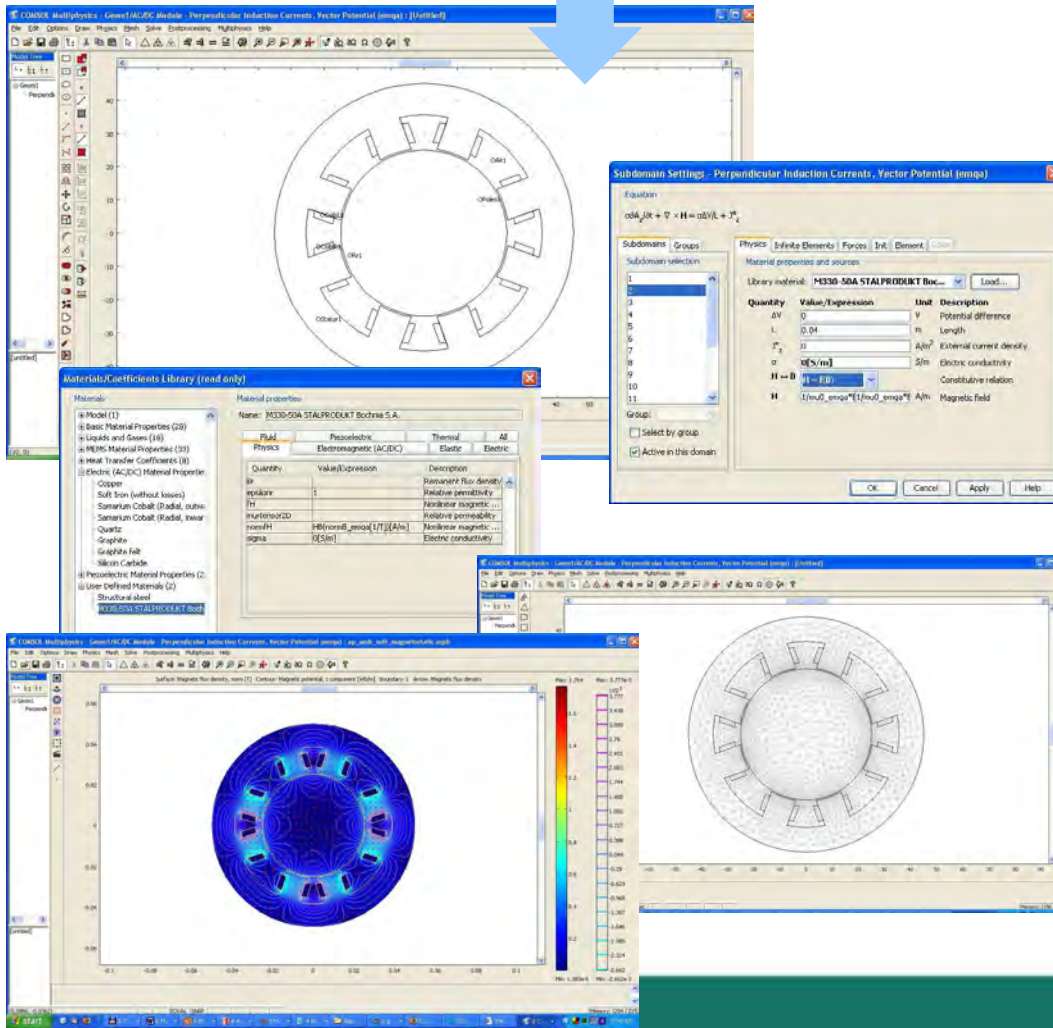


# FEM analysis

Manual

Automatic (programmable)

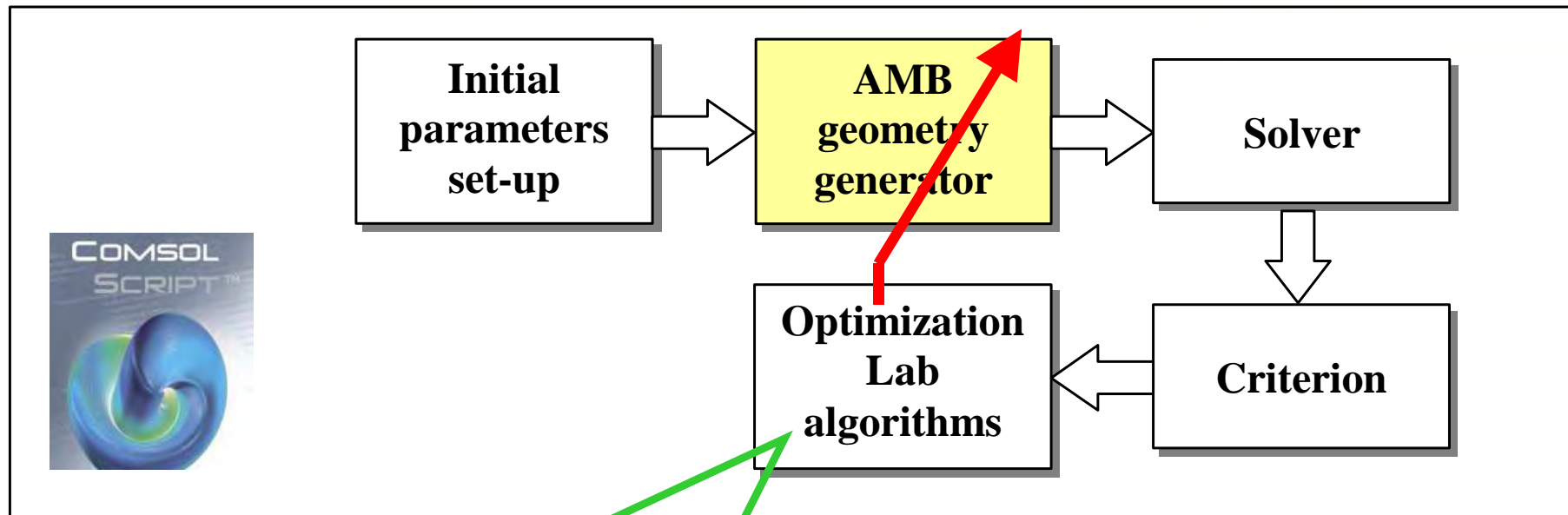
Geometry generator



With fem do

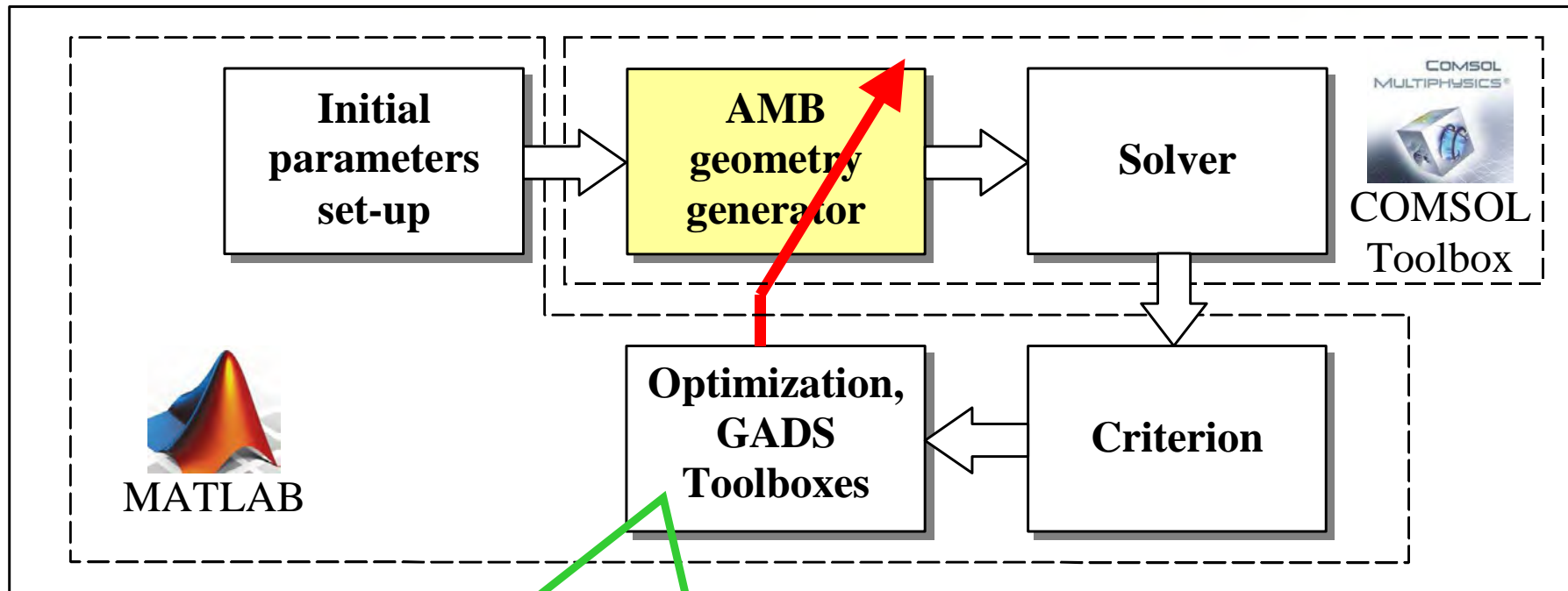
- select application mode
- assign geometry objects
- assign parameters and equations
- initialize mesh
- solve
- analyze results using post processing functions

# Optimization



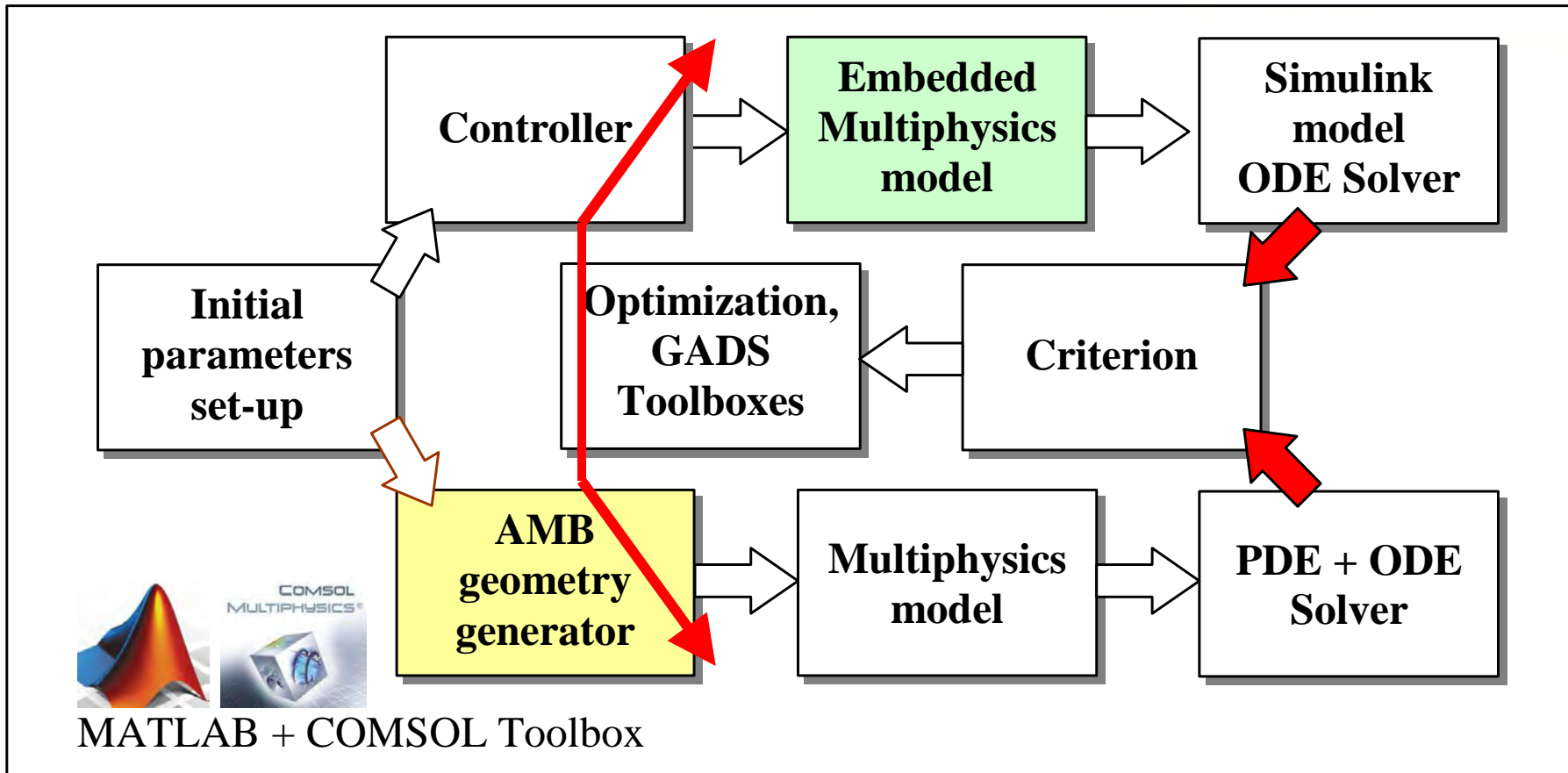
Linear and nonlinear solvers  
linear and nonlinear constraints

# Optimization

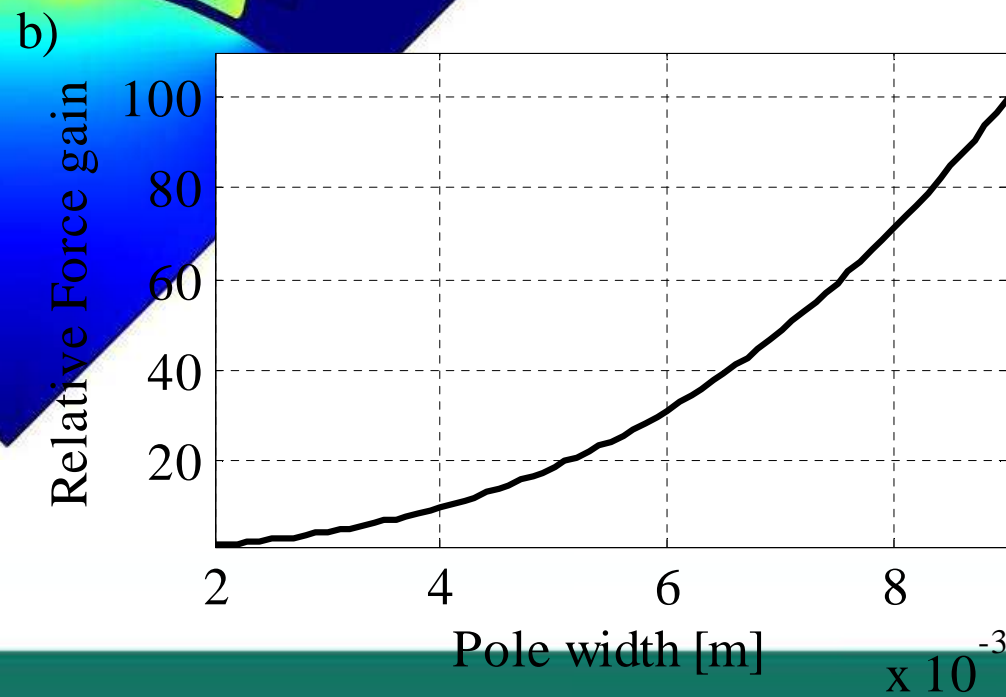
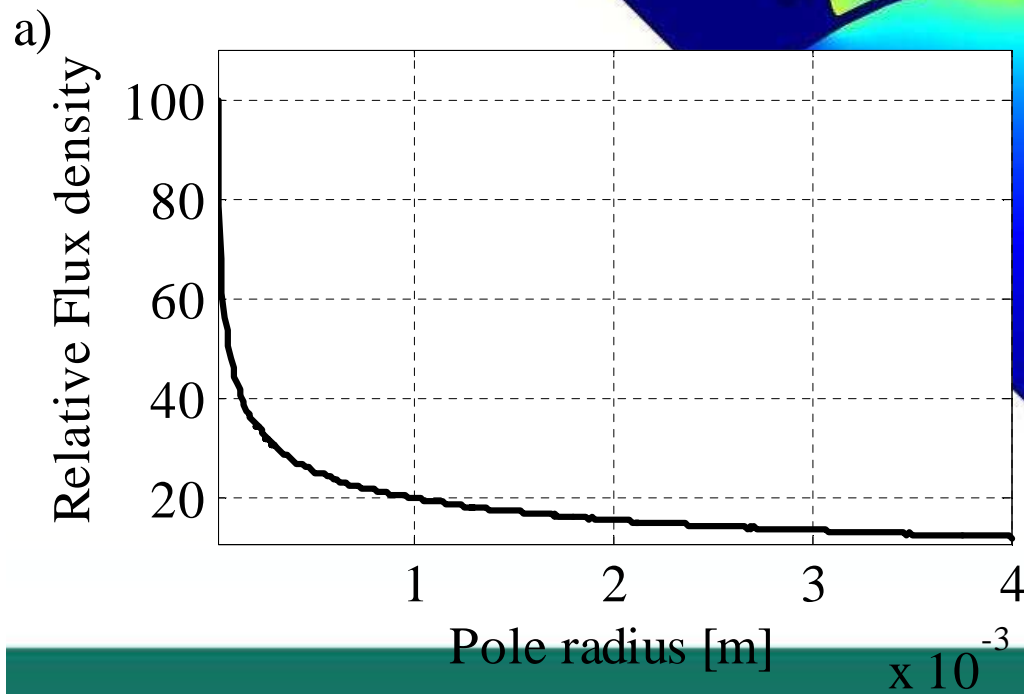
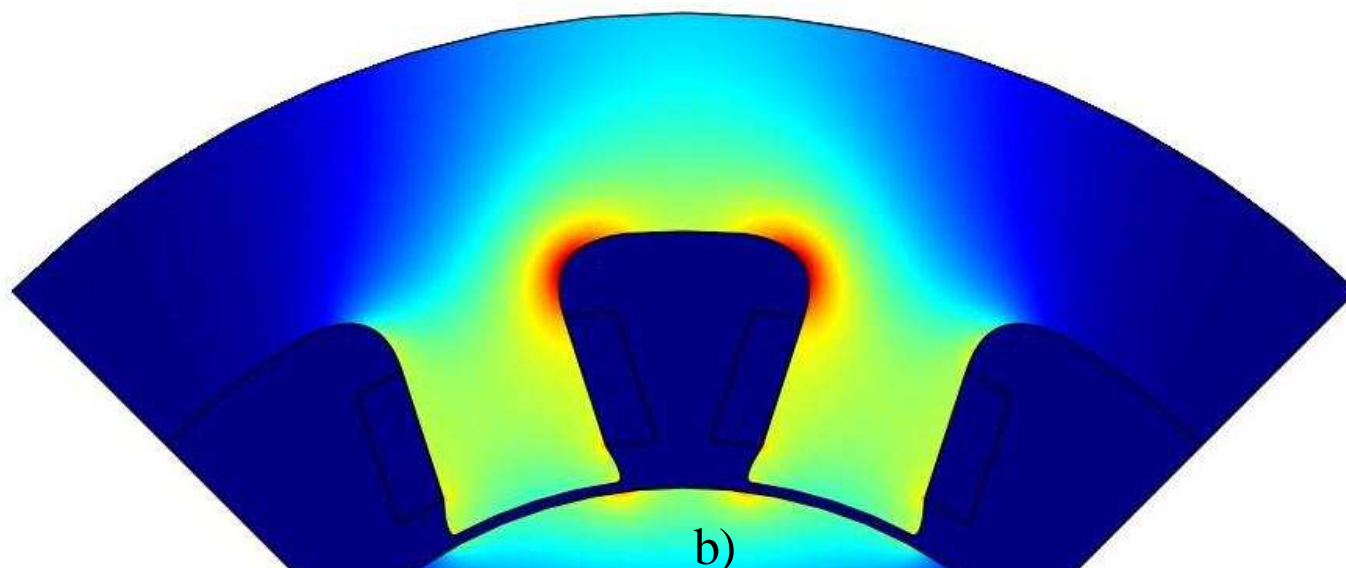


Linear and nonlinear solvers  
including Genetic Algorithms  
linear and nonlinear constraints

# Optimization



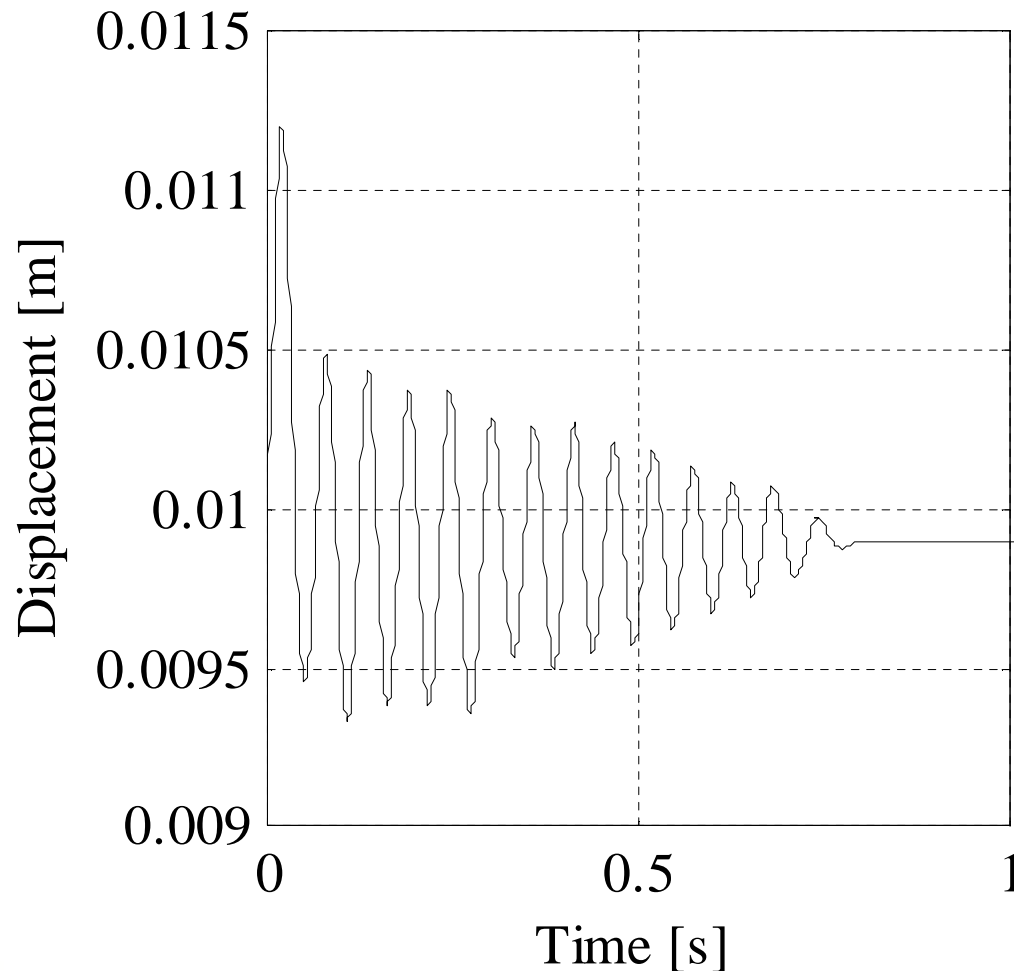
# Example







# Position of the levitated object steered by the PD controlled – both implemented in COMSOL Multiphysics.





## Conclusions

- ▲ Design, modelling and simulation
  - Modelling as is – geometry, materials
  - PDE + ODE
  - Optimisation

- 
- ▼ Computational effort
    - Controller architecture
    - Real-time calculation
    - Simulink data exchange and link
- 

**To Do:**

**Rotor axial motion and rotation in the AMB plane**



*Thank You for Your Attention*