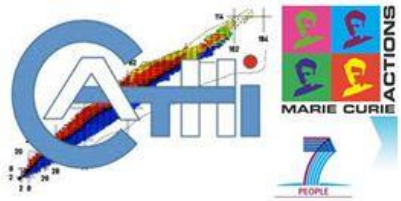


New electromagnets for HIE-ISOLDE: from conceptual design to magnetic compatibility studies

PANAGIOTIS FARANTATOS(TE/MSC-MNC)*
WP3, ESR 4: New Magnet

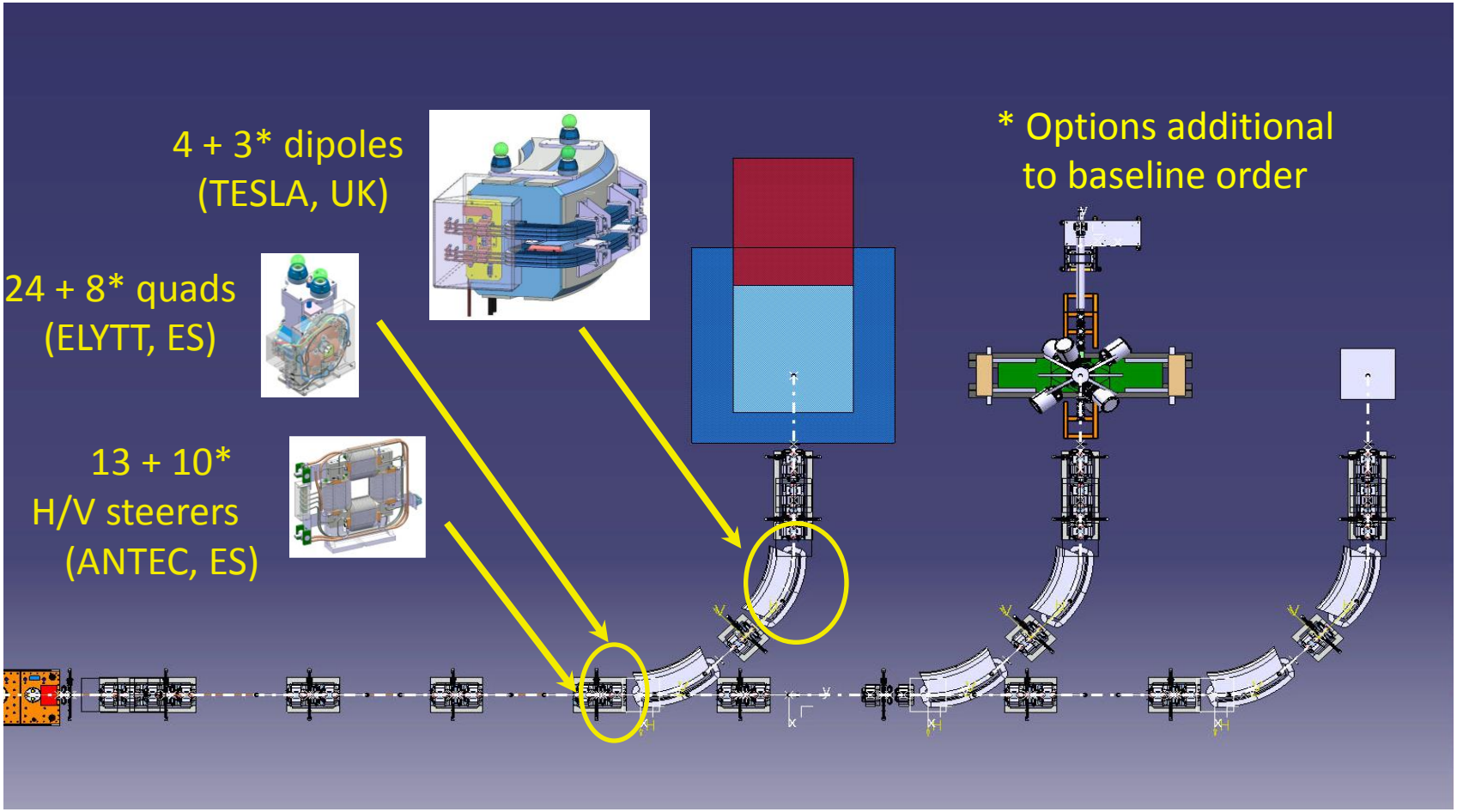
HIE-ISOLDE Workshop: The technical aspects, 28th November 2013

* The research project has been supported by a Marie Curie Early Initial Training Network Fellowship of the European Community's Seventh Programme under contract number (PITN-GA-2010-264330-CATHI)

Selection of topics

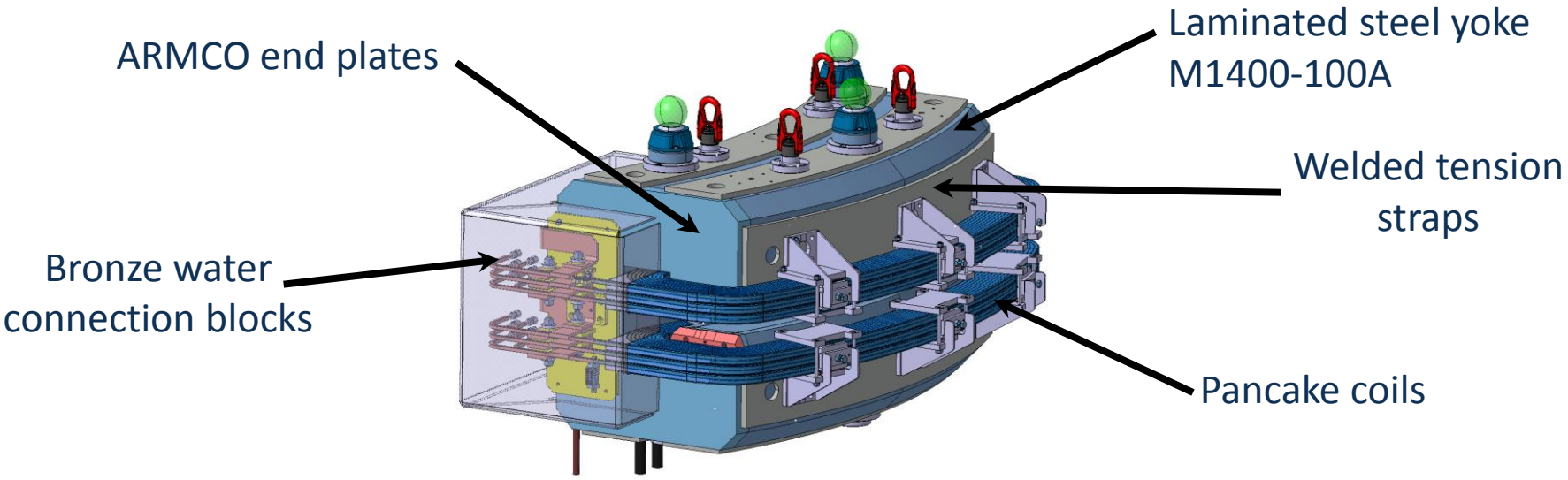
- HIE-ISOLDE: Magnets' Requirements
- Magnetic Design (quad)
- Magnetic Compatibility
- Secondment DTU-ELEK: Magnetic Couplings

The **HIE-ISOLDE** magnets



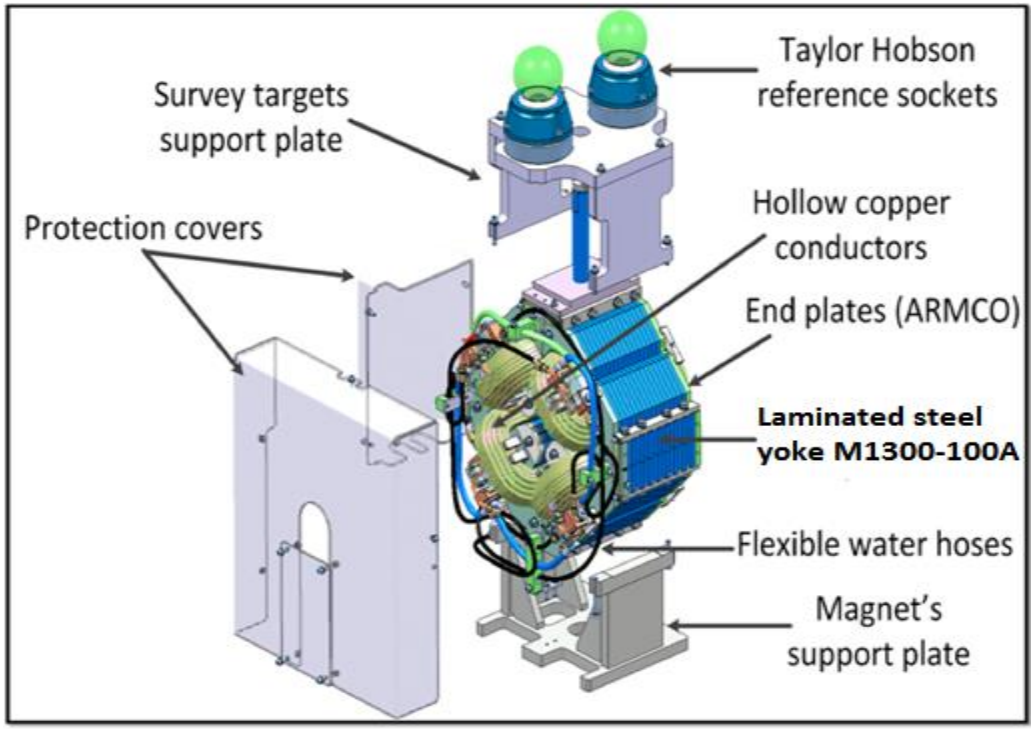
Dipole

Bending radius [m]	Deflection angle [deg]	Field in centre [T]	Integrated field [Tm]	Magnetic length [m]
1.8	45	0.11 - 1.14	0.15 - 1.61	1.414



Detailed in "Magnets" presentation at ***HIE-ISOLDE HEBT Technical Design Review, 6th July 2012***

Quadrupole

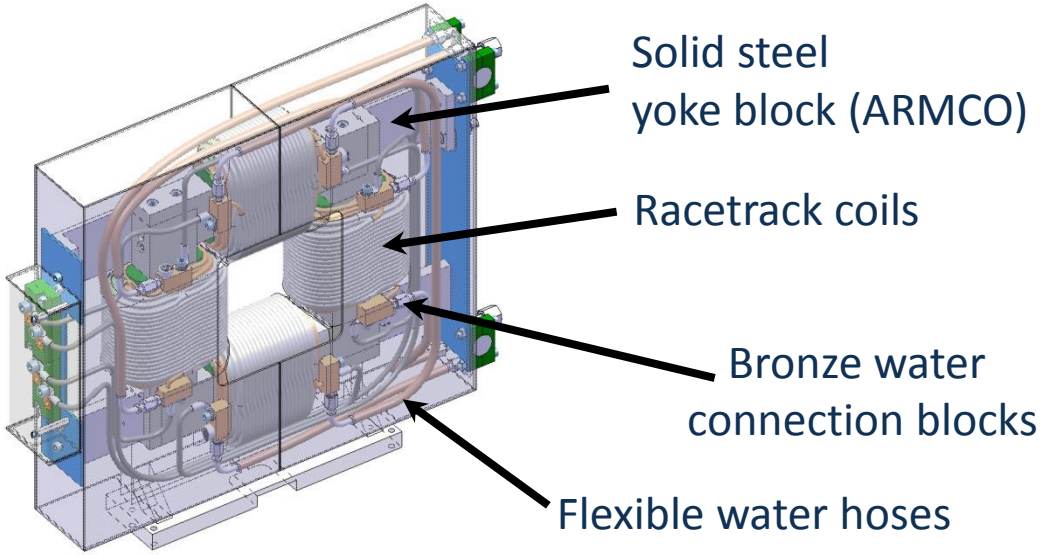


Gradient [T/m]	0.5 - 25
Integrated gradient [T]	0.1 - 5.0
Aperture radius [mm]	25
Magnetic length [mm]	200

Detailed in "Magnets" presentation at ***HIE-ISOLDE HEBT Technical Design Review, 6th July 2012***

H/V Steerer

Integrated field [Tmm]	Magnetic length [mm]	Physical aperture [mm x mm]	Physical length [mm]
9.1 (LINAC) 6 (HEBT)	256	90 × 90	92

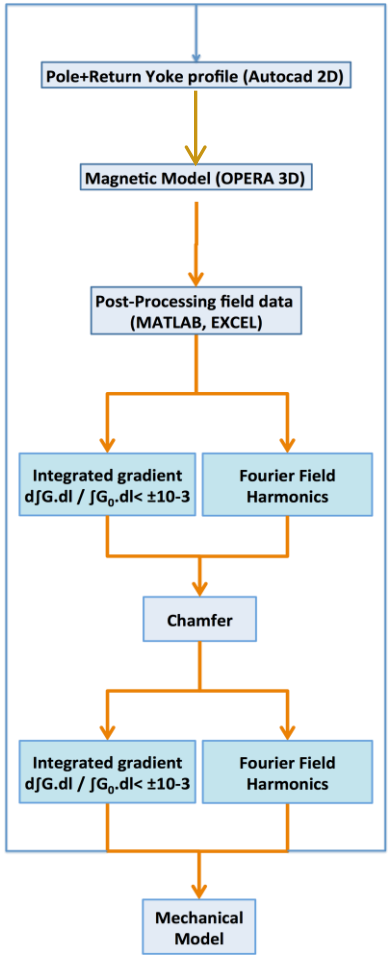


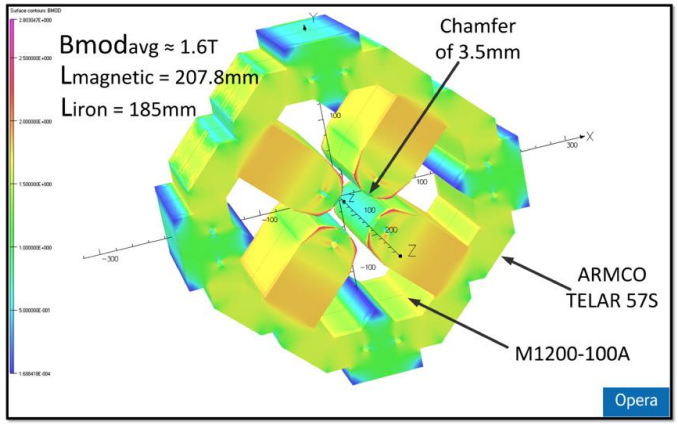
Detailed in "Magnets" presentation at ***HIE-ISOLDE HEBT Technical Design Review, 6th July 2012***

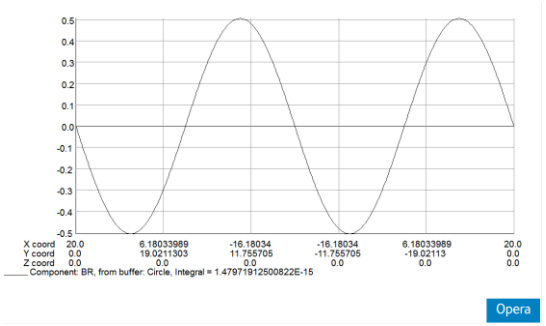
Engineering Interfaces

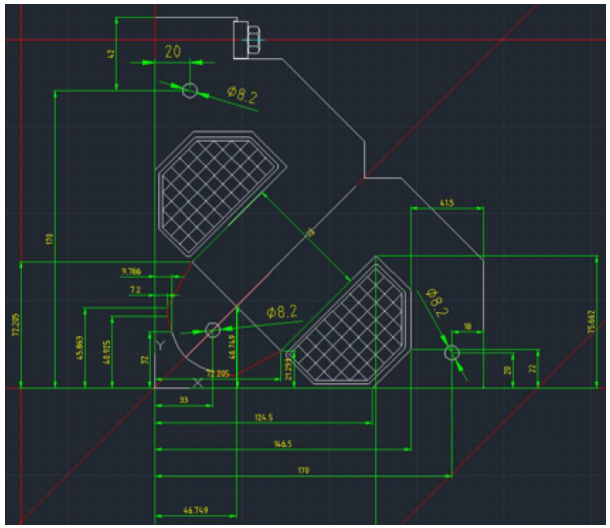
- Requirements imposed by other pieces of equipment
- Vacuum chamber: Aperture diameter
  - Diameter, thickness, installation margin, assembly tolerance
- Power Converters: Peak current, Inductance
  - $E_{stored} = \frac{1}{2} L I^2$
- Cooling: Water pressure limit
  - Parametric study of cooling parameters

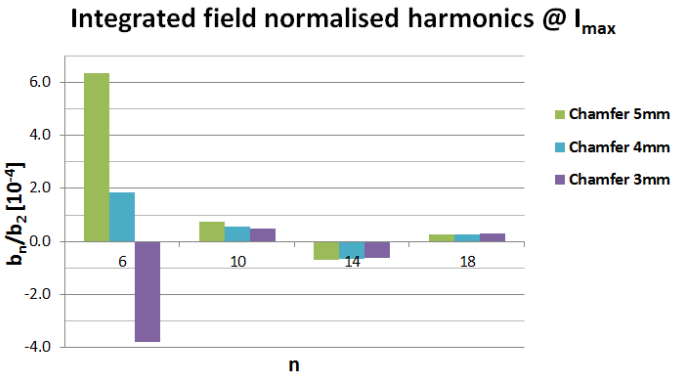
Magnetic Design (Quads)



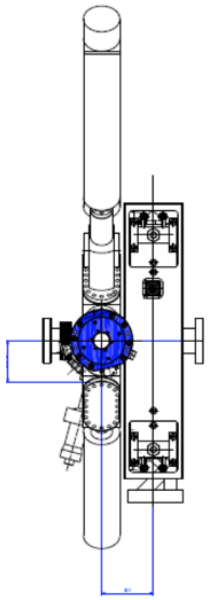




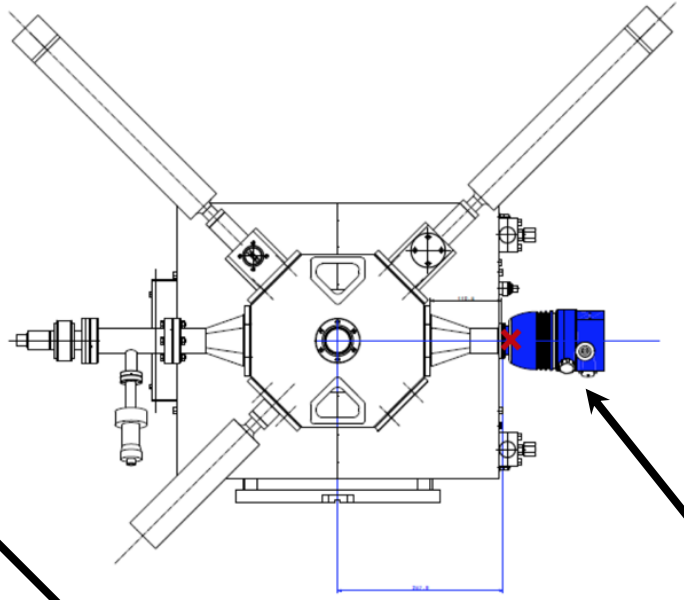




Integration study: Turbo-pump

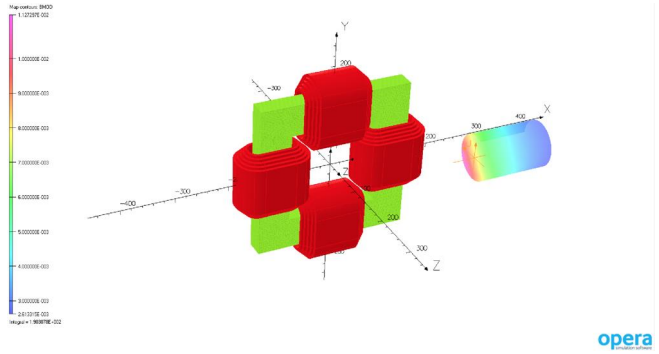


81 mm



258 mm

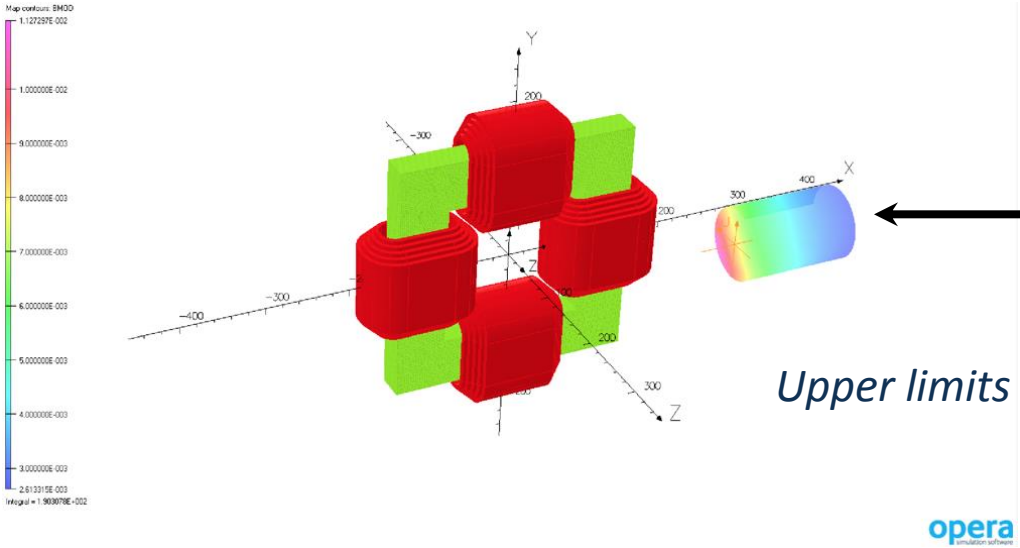
H/V steerer

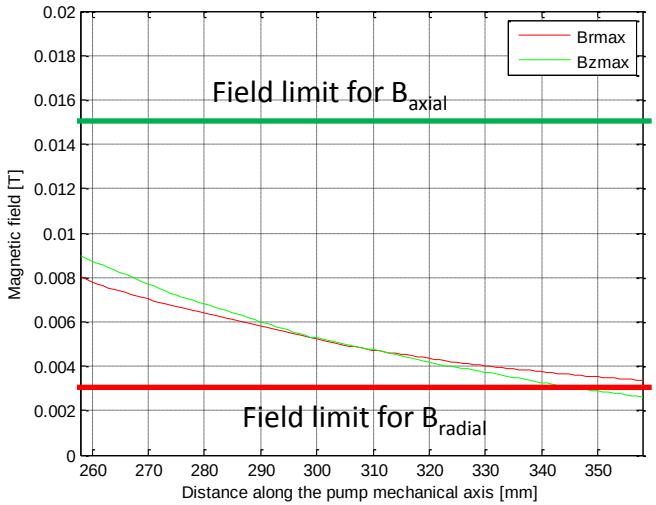


Turbo-pump: Potential **perturbation** on its operation due to interference with steerer's **stray** magnetic field

Integration study: Turbo-pump

Stray field distribution along vacuum pump's envelope





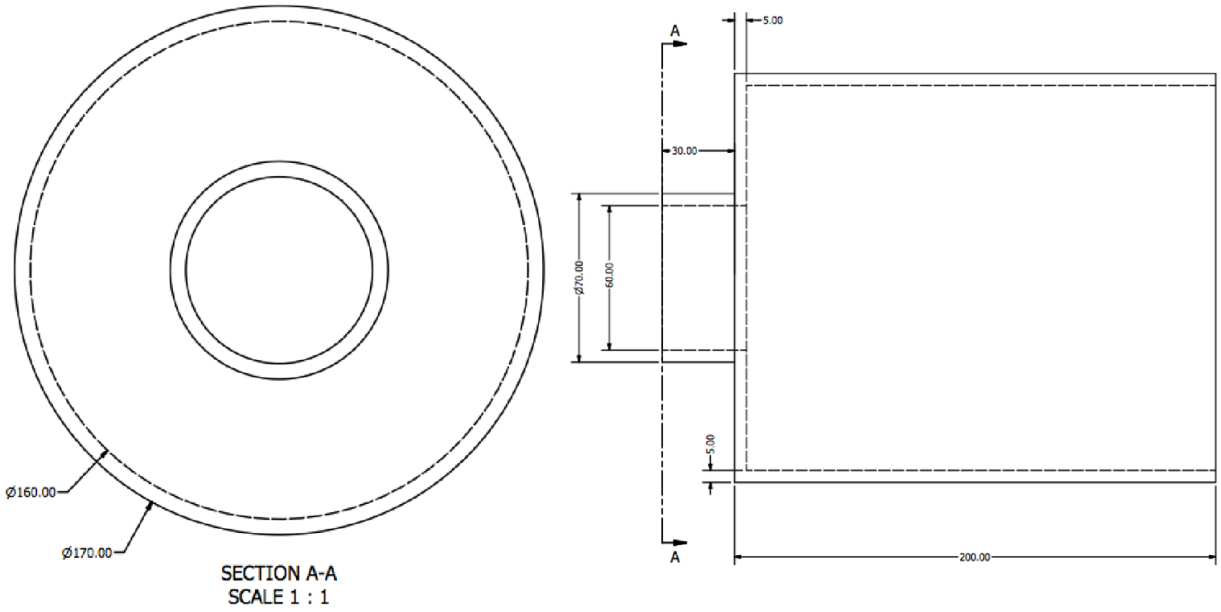
Field component	Operational limit of pump
Radial field (Br)	3 mT
Axial field (Bz)	15 mT

Solutions:

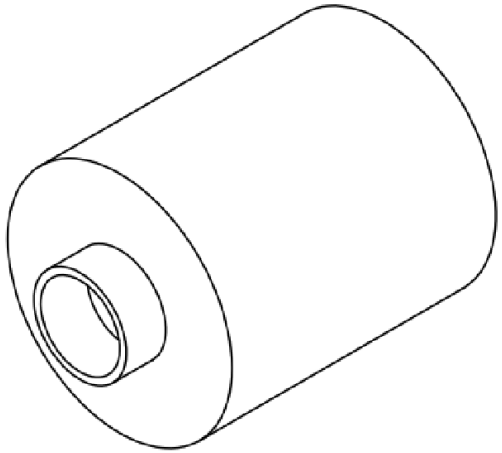
1) Move turbo-pump 100mm away
2) Shielding

Turbo-pump: Shielding

Material: 1010 steel

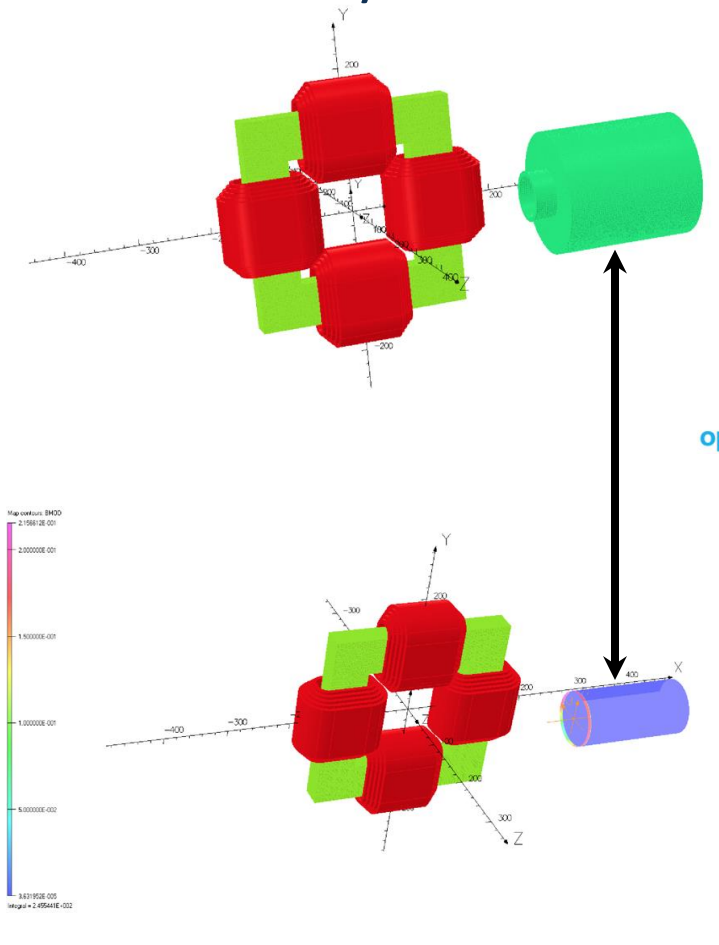


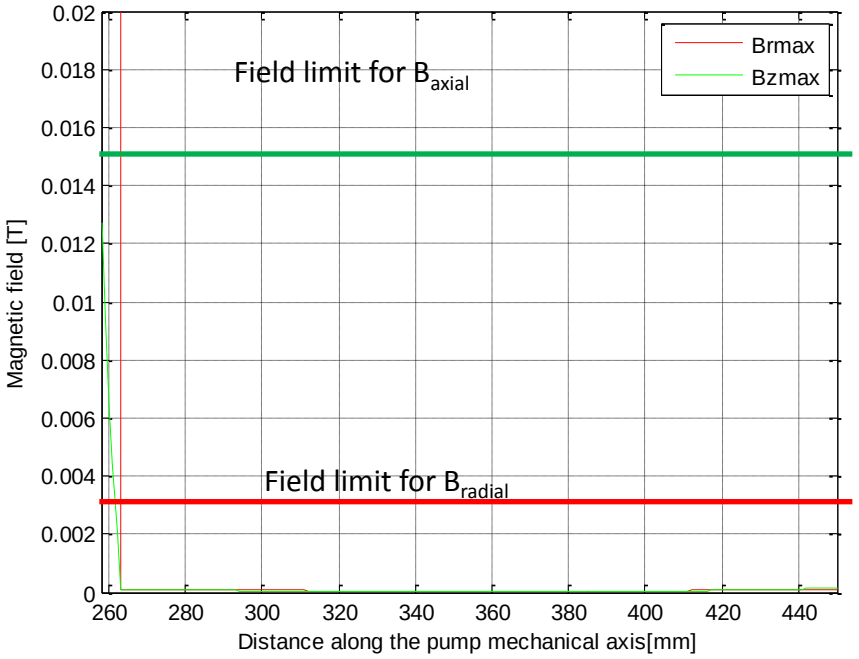
1010 steel VS Mu-metal
Excellent saturation
No need for thermal treatment after machining
Less expensive
Lighter



Turbo-pump: Shielding

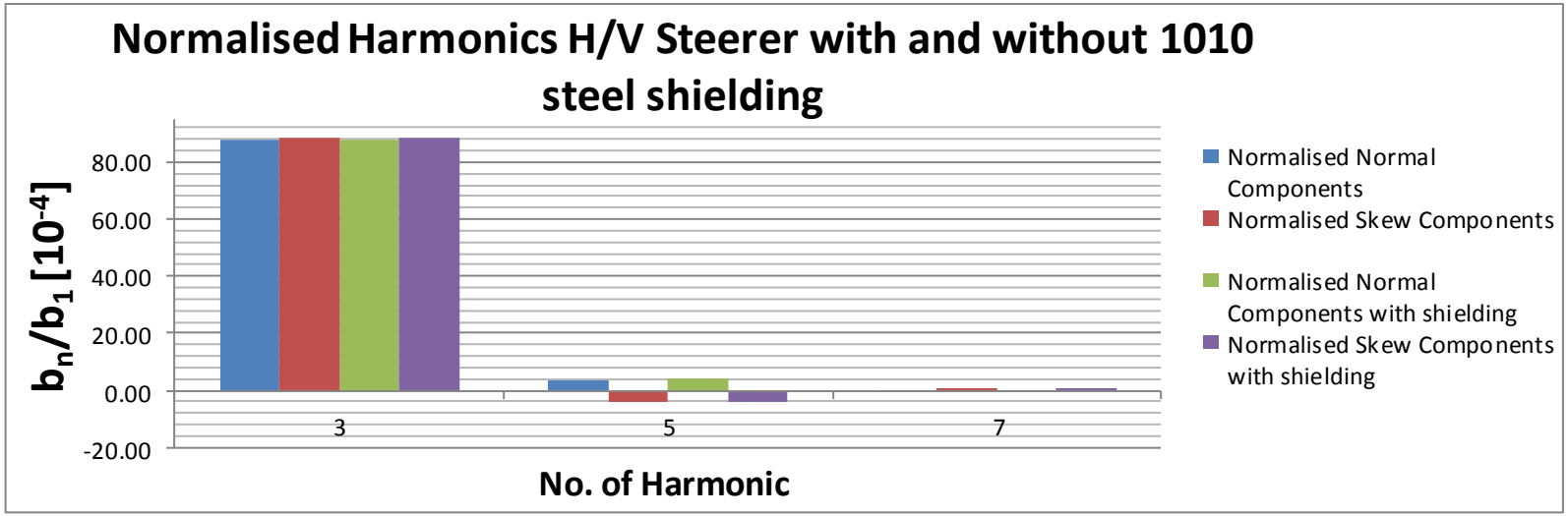
Stray field distribution along turbo-pump envelope





Safe operation for turbo-pump

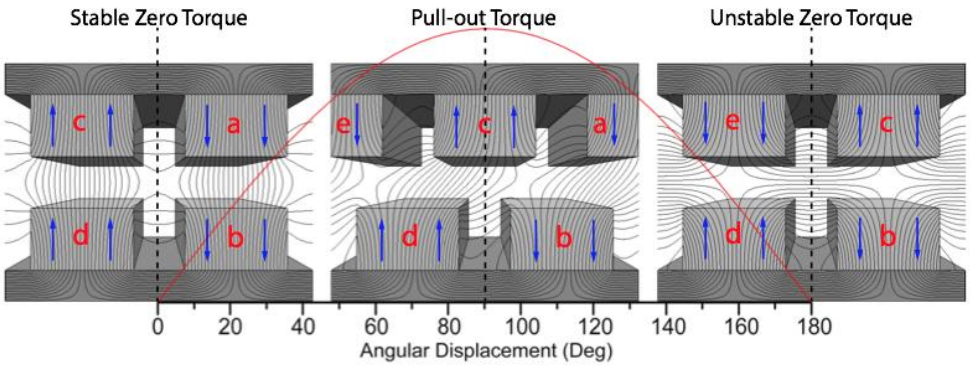
Turbo-pump: Shielding



Shielding **does not** affect the steerer's field quality

Secondment to DTU-ELEK

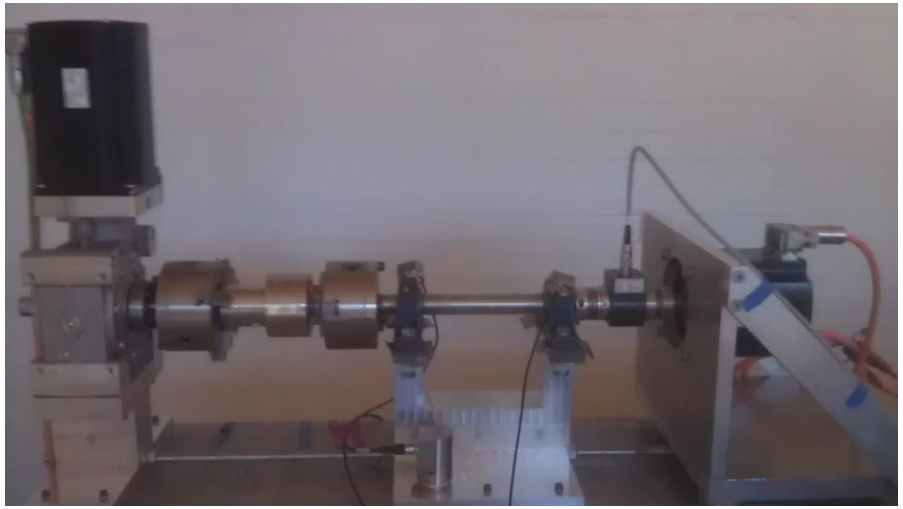
- Magnetic Couplings
  - Transmitting torque through air
  - High efficiency
  - Robust
  - Overload protection
  - Widely used in pump systems



Hoegberg et al. I*mproving torque per kilogram magnet of permanent magnet couplings using finite element analysis*. *IEMDC 2013 IEEE International*, 1074-1079

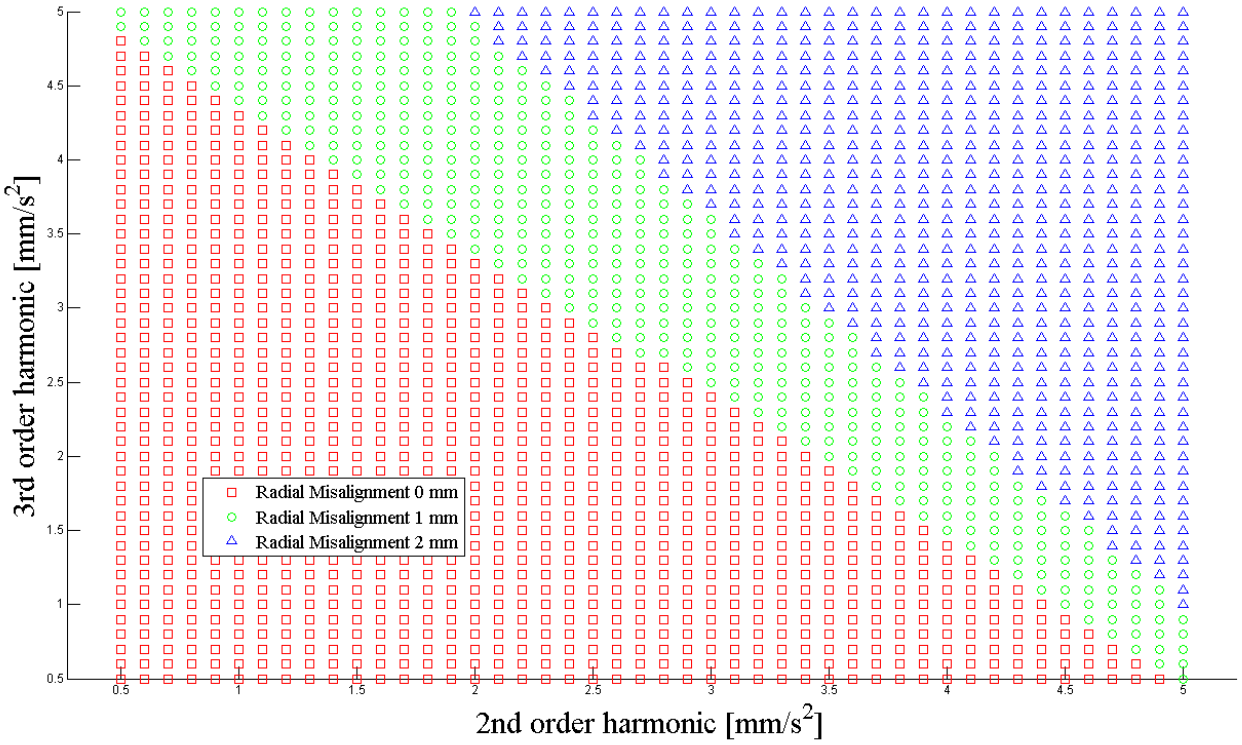
Secondment to DTU-ELEK

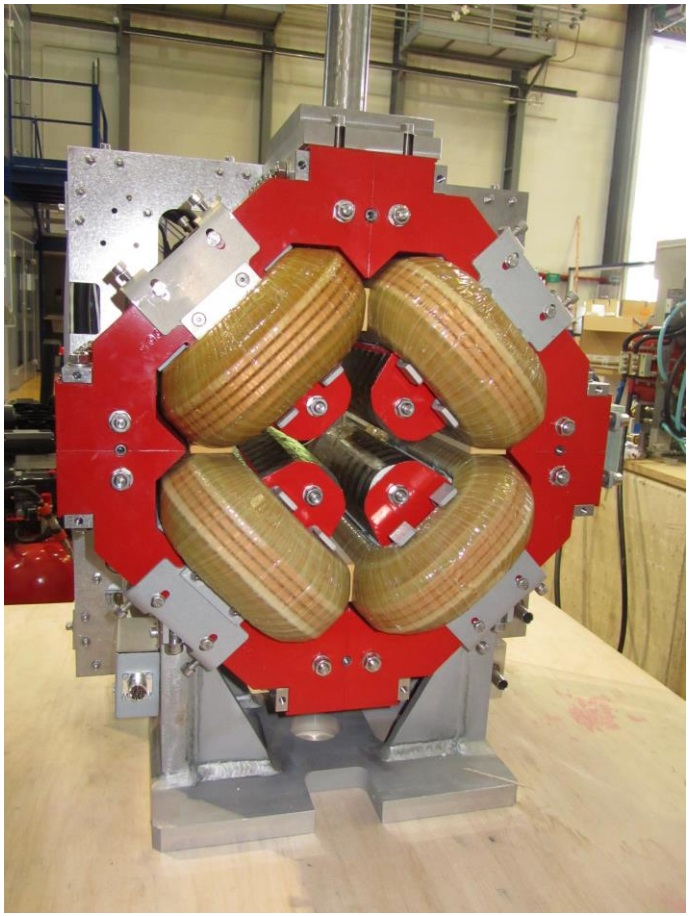
- Numerical (FEA) and experimental torque performance assessment of dynamic operation of NdFeB rare-earth permanent magnetic couplings
- Misalignment conditions
- Vibration pattern analysis



Secondment to DTU-ELEK

- Running Speed Harmonics



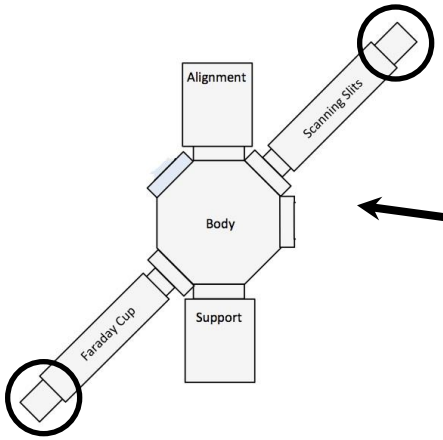


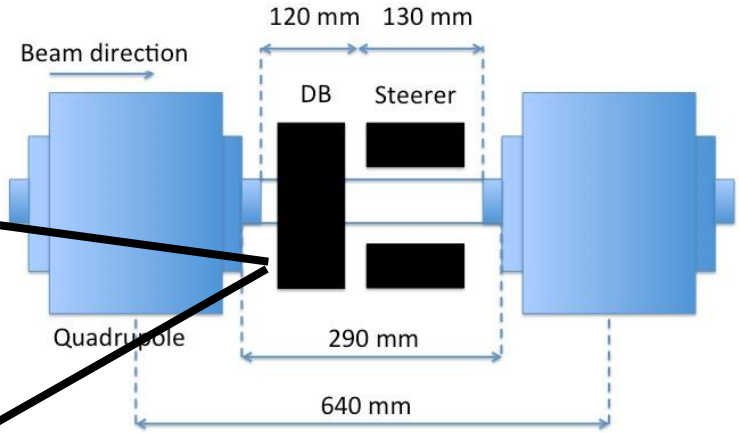
Thanks for your attention!

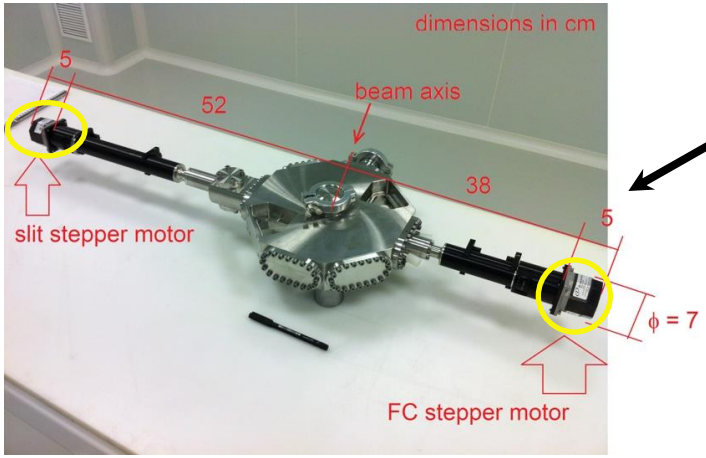
Magnetic Design (Quads)

- 2D Lamination Profile
- 3D FEA Modeling
  - Magnetic properties sensitivity analysis
- Post-Processing FEA: Field Quality Assessment @GFR
  - Integrated Gradient Error
  - Fourier Coefficients, DFT
  - Field Quality Optimization
    - Chamfering (local effect)
    - Dedicated Pole Profile (global effect - initialization)

Integration study: Stepping motor







Potential perturbation on DB's stepping motors' operation due to steerer's stray magnetic field

Integration study: Stepping motor

Stray field distribution along stepping motor envelope