

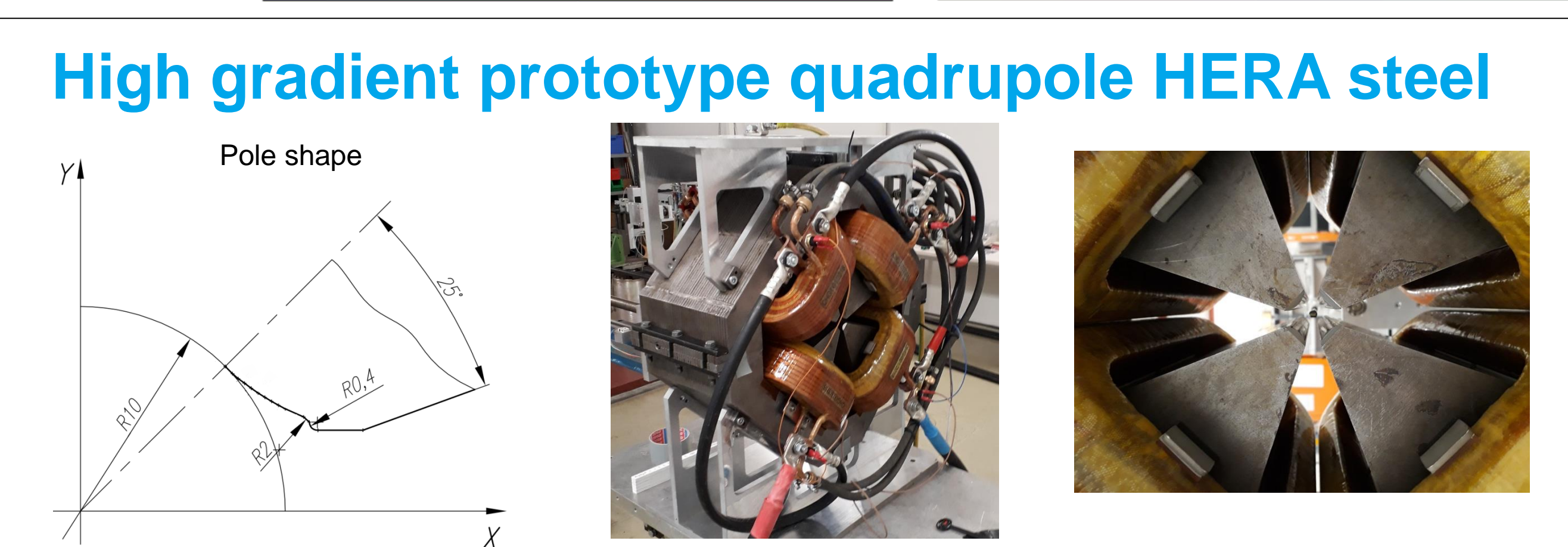
# Research and Development PETRA IV Magnets, Girders and Vibrations.



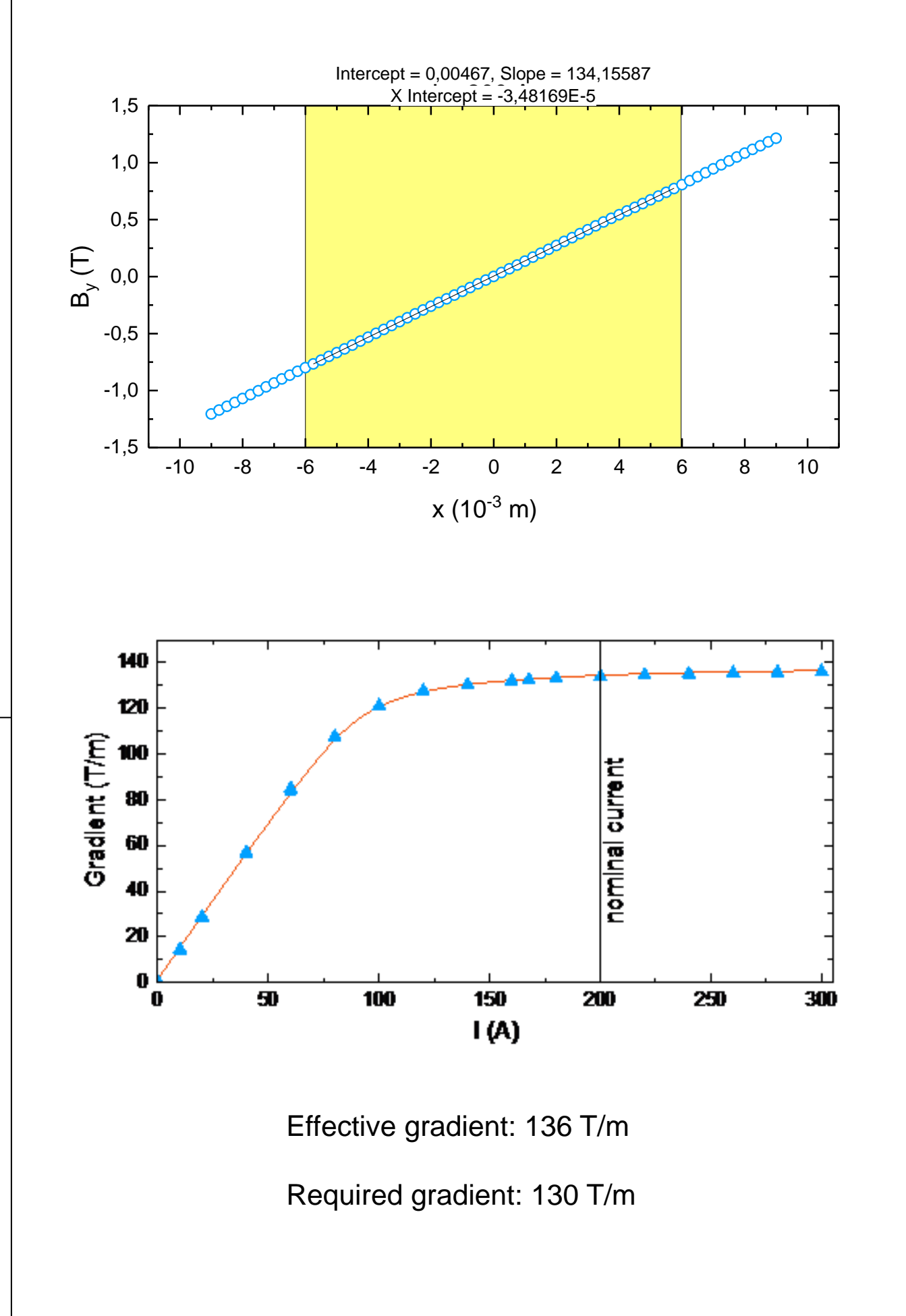
S. Andresen, M. Körfer, B. Krause, N. Meyners, A. Petrov, M. Thede

## High gradient quadrupole calculations

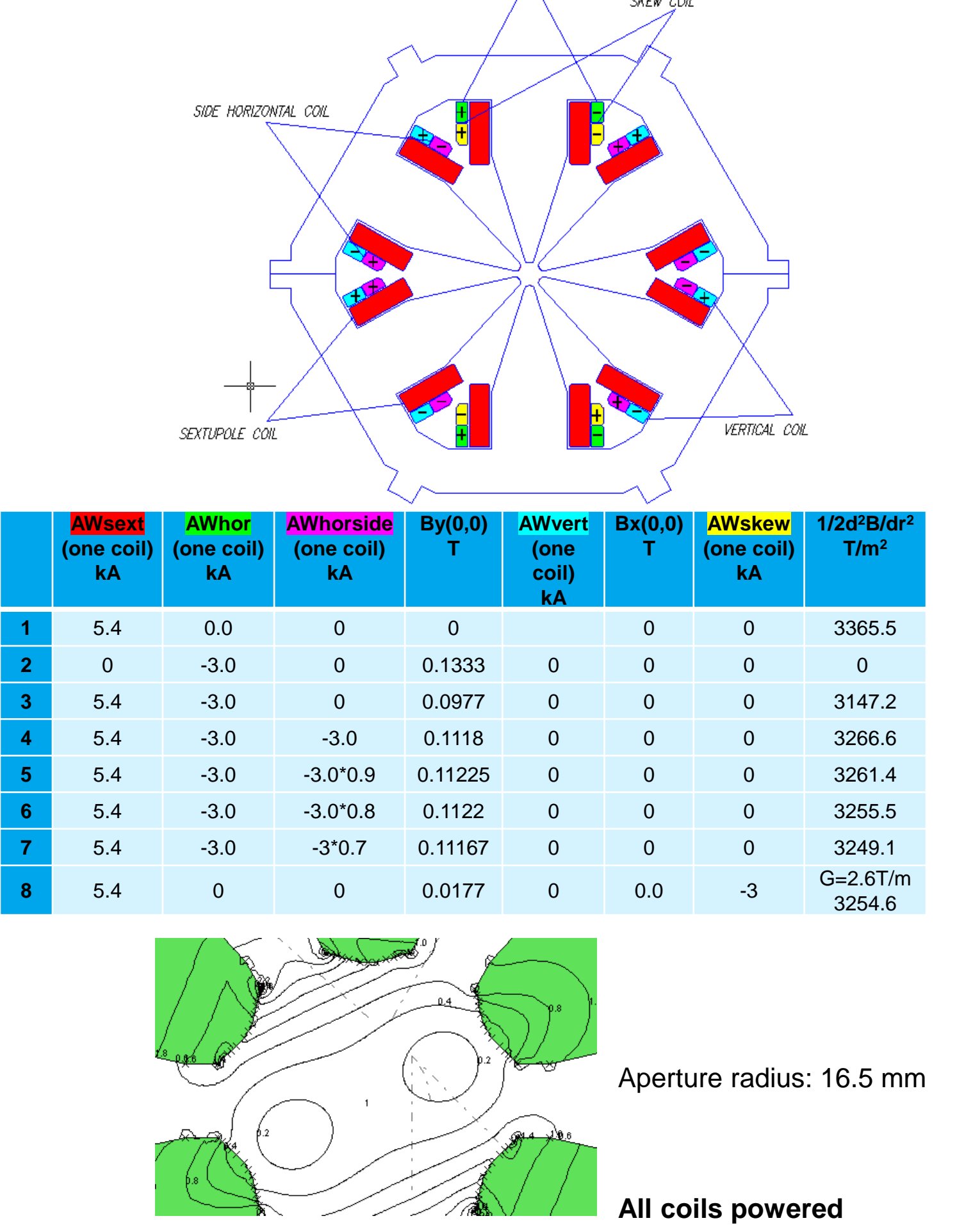
Material	HERA Steel	PowerCore 1200	PowerCore 1400	PowerCore H125-35	PowerCore H110-30	Vacoflux 50 (Pole)	Vacoflux 27
Gradient [T/m]	132	122	133	123	123	145	155
Comments	Similar to ARMCO	Standard product	New product	good axis stability	good axis stability	Very expensive 100 €/kg	new product, expensive



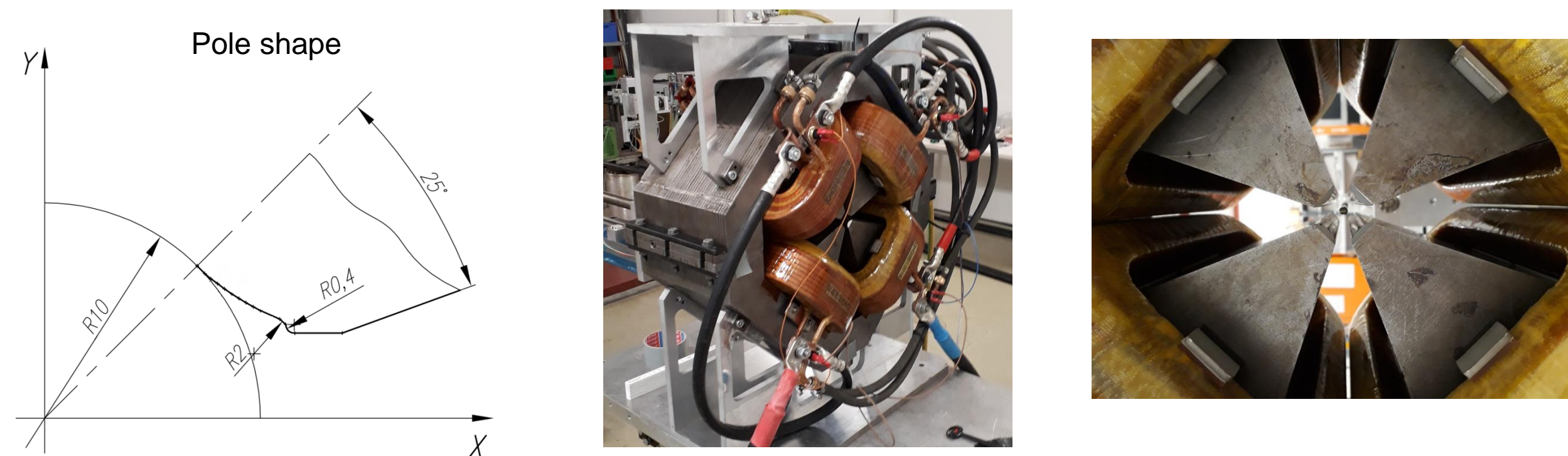
## High gradient quadrupole measurements



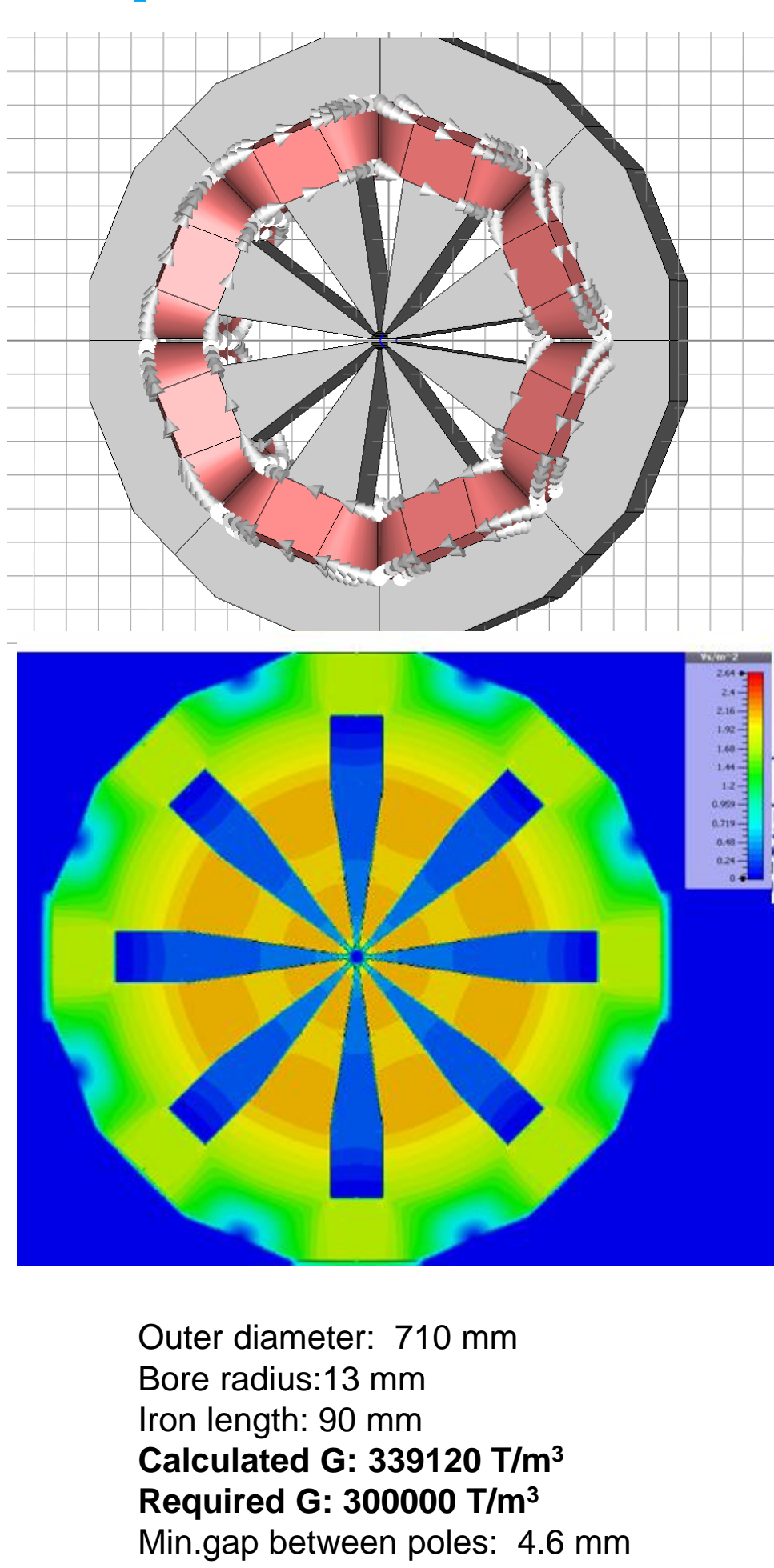
## Combined function sextupole



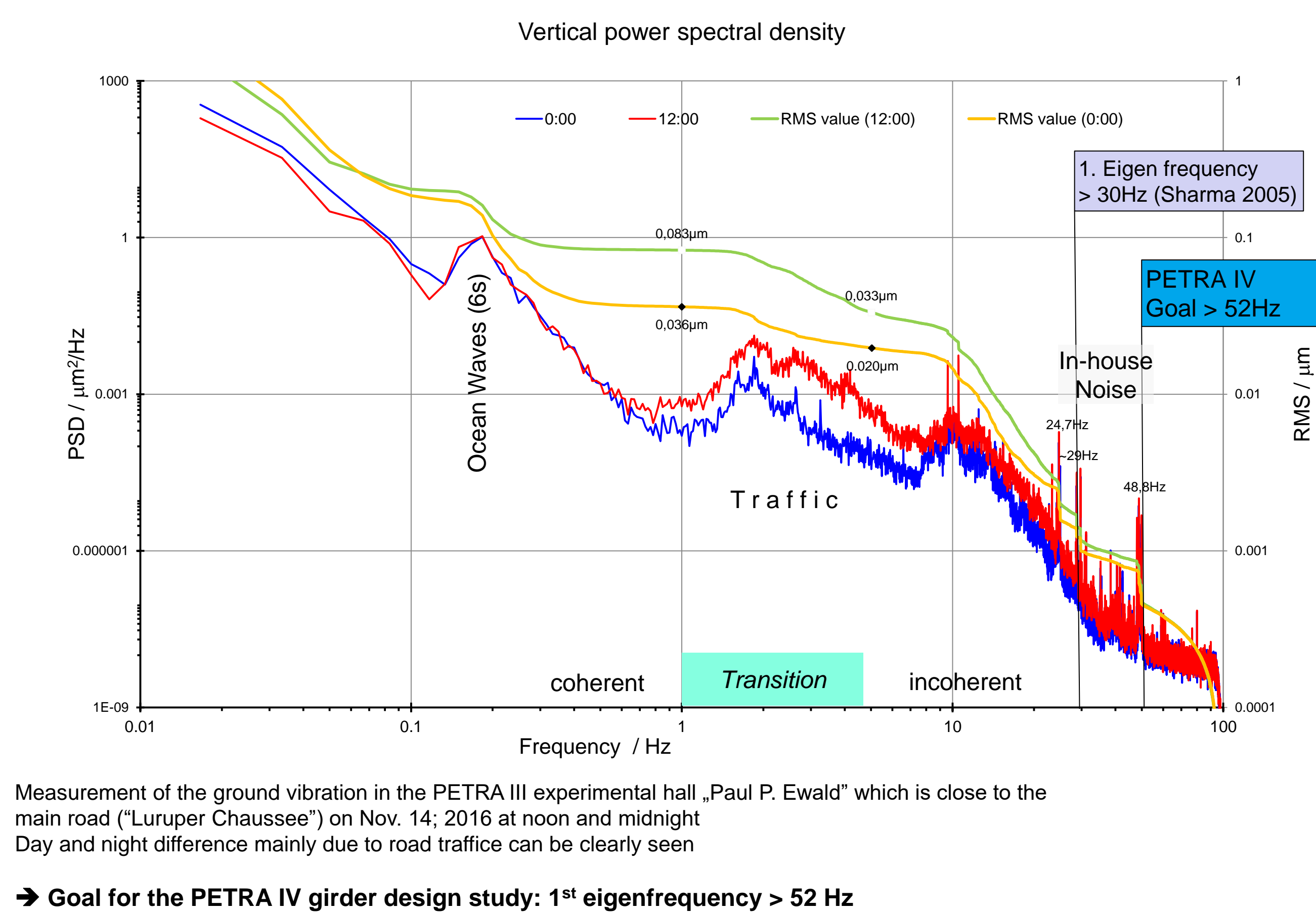
## High gradient prototype quadrupole HERA steel



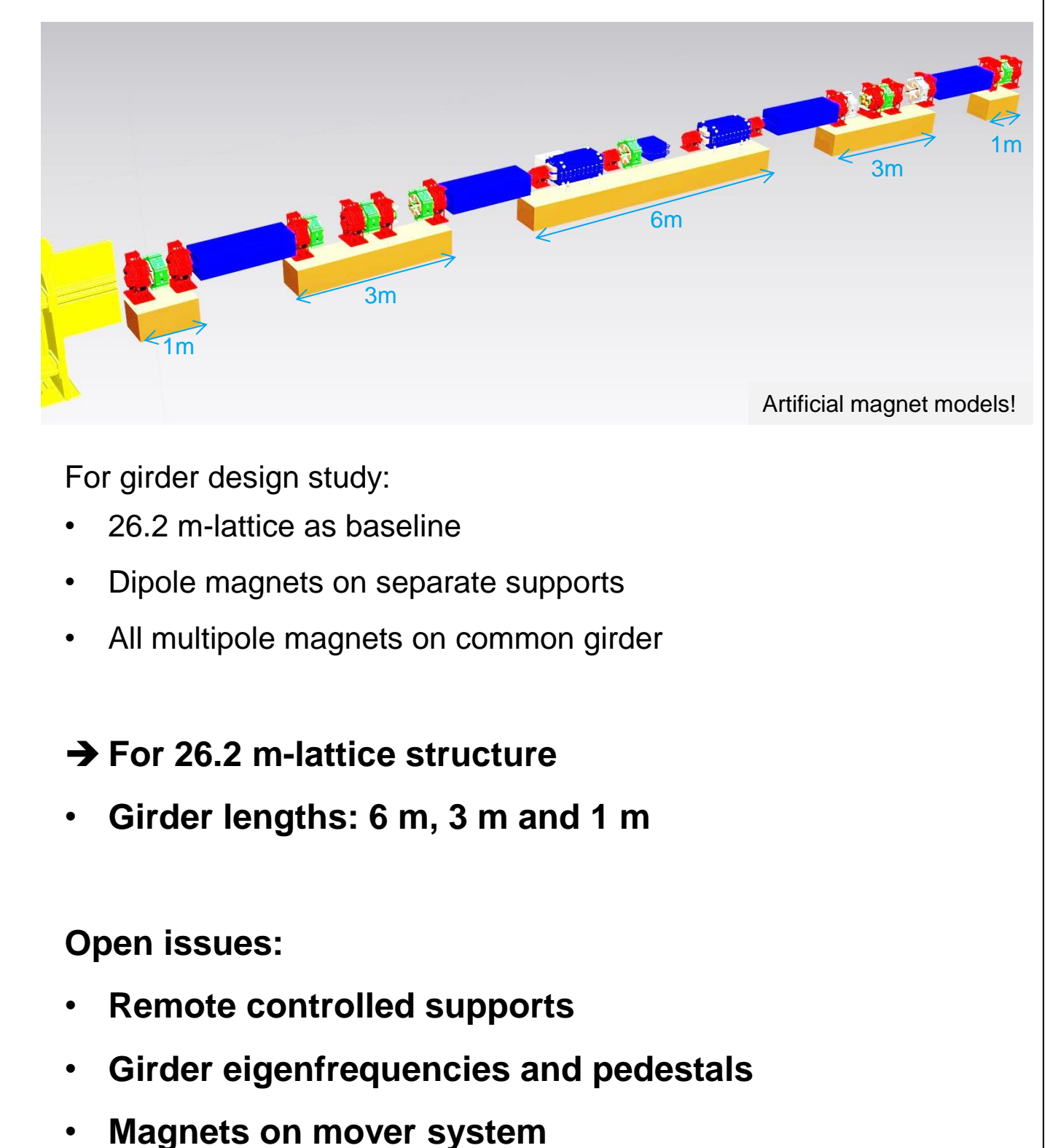
## Octupole calculations



## Ground vibration at DESY



## PETRA IV girder length (26.2 m-lattice structure)



## Different approaches to the PETRA IV girder design



**Research project**

The project is conducted in cooperation with the research section "Bionic lightweight design and functional morphology" of the Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research (AWI), which has a high expertise in bionic lightweight design and structural optimization.

**Project goals**

- Development of different designs for the PETRA IV girders with high eigenfrequencies above 52 Hz, high static stiffness and low structural mass (< 2500 kg)
- Fabrication of girder prototypes
- Prototype measurements and validation of simulations

**Design space**

The girder design space (grey) was based on a PETRA III girder (4.2 x 0.65 x 0.525 m). Three magnets of 1.2, 1.8 and 1.2 t mass were included each apportioned among four points. The girder bases were neglected.

**Biologically inspired lattice structures**

Irregular lattice structures are widely spread in nature. The shells of marine protozoa show an enormous diversity of irregular lattice structures which are not just inspiration for lightweight designs, but also expected to positively influence the vibration characteristics.

**Topology optimization**

Topology optimizations are used to identify an optimal design of a structure within a specified design space. The resulting structure meets the defined goals at lowest possible mass.

Topology optimization result

**Structural optimizations based on evolutionary strategy**

Starting with the topology optimization result, further optimizations aiming at the defined goals lead to structures with improved properties. The used evolutionary strategy is based on the principles of evolution involving selection, mutation and crossover.

**Comparing the different approaches**

The figure stated below summarizes the 1<sup>st</sup> eigenfrequency, stiffness and mass of the three structures. The values are normalized by the reference values obtained for the PETRA III girder and displayed above each bar.

Approach	1st eigenfrequency	Stiffness	Mass
Bio-inspired lattice	2.2	9.1	1.3
Topology optimization	1.3	2.5	0.4
Evolutionary strategy optimization	1.9	7.6	1.0
Reference: PETRA III girder	1.0	1.0	1.0

Andresen, S. (2018): "Optimizing the PETRA IV girder by using bio-inspired structures", in Proc. MEDSI'18, Paris, France.