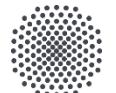
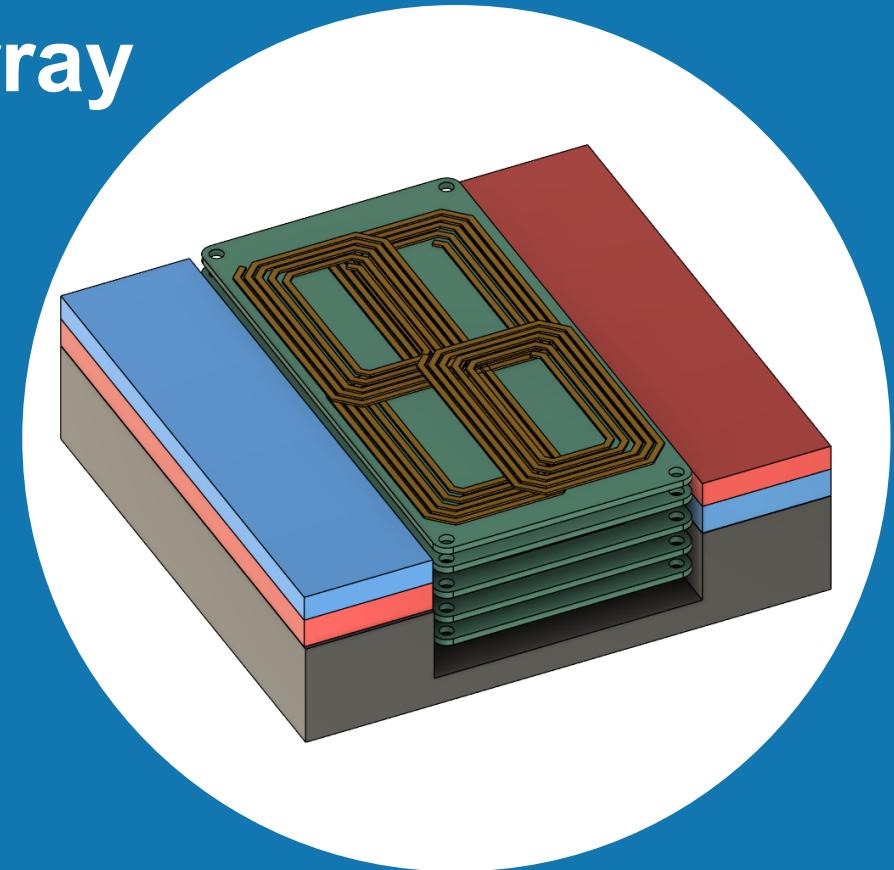


Portable PYNQ-based Phased-Array Single-sided NMR System

Jiaxun Song

Mid-term Presentation of Master Thesis

20/10/2025

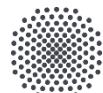


University of Stuttgart

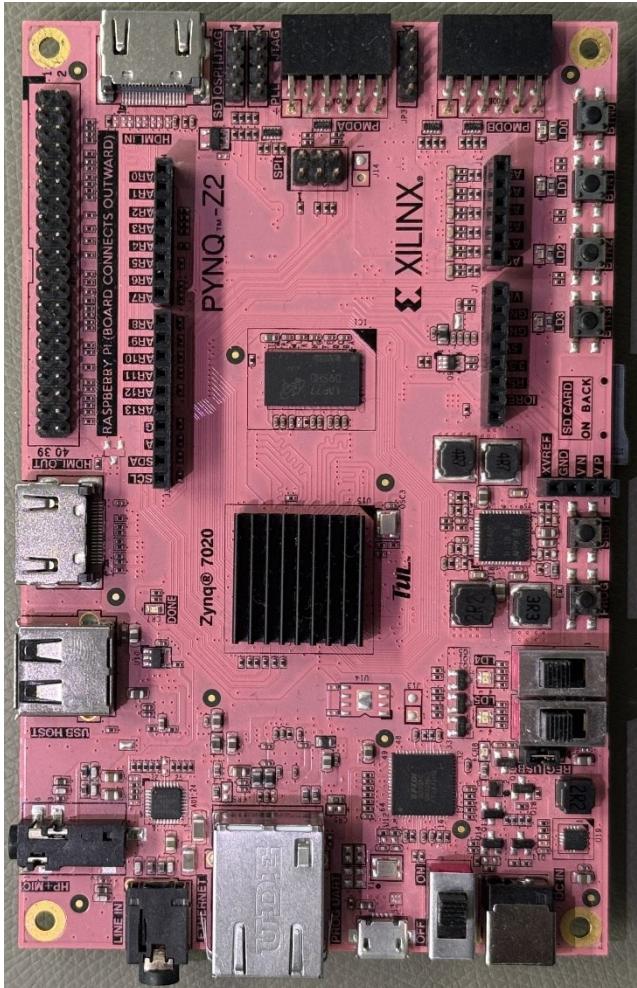
Jiaxun Song – Portable PYNQ-Based Phased-Array Single-sided NMR Design



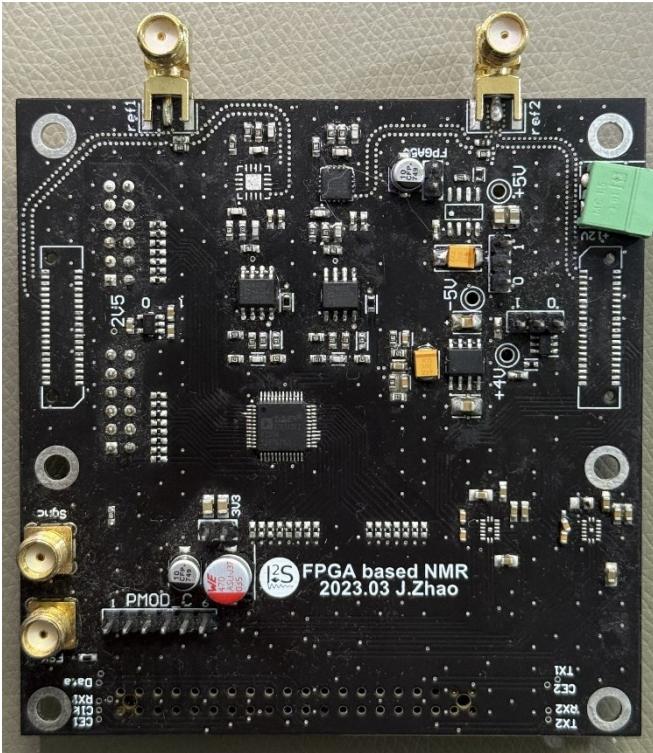
- Background
 - Overview of the previous PYNQ-Z2 based design
 - Motivation for upgrading to Kria K26 platform
- System Model Overview
 - 3D visualization of the design concept
 - Design highlights
 - Application prospects
- Electrical Architecture
 - Kria K26 SOM and hardware design
 - Communication and power management module
 - Analog and driver circuit design
- Magnetic and Coil Design
 - Phased-Array coil assembly using CST
 - Single-sided magnet design
- Power Supply and Energy Estimation
- Future Work



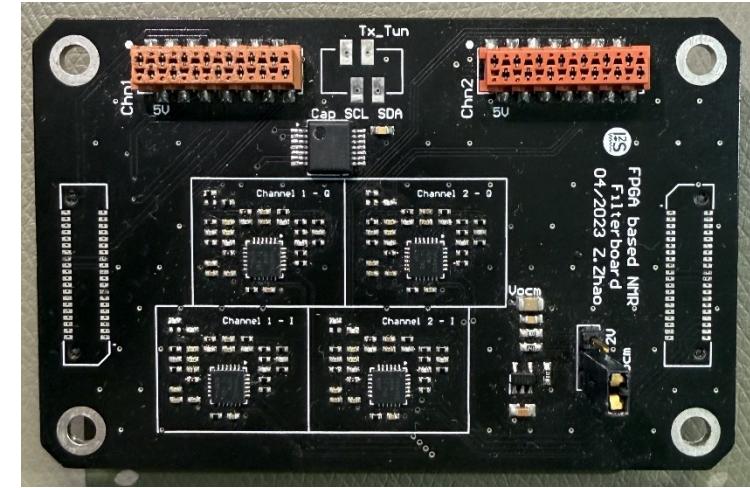
- Overview of the previous PYNQ-Z2 based design



PYNQ-Z2



DAC and ADC Board

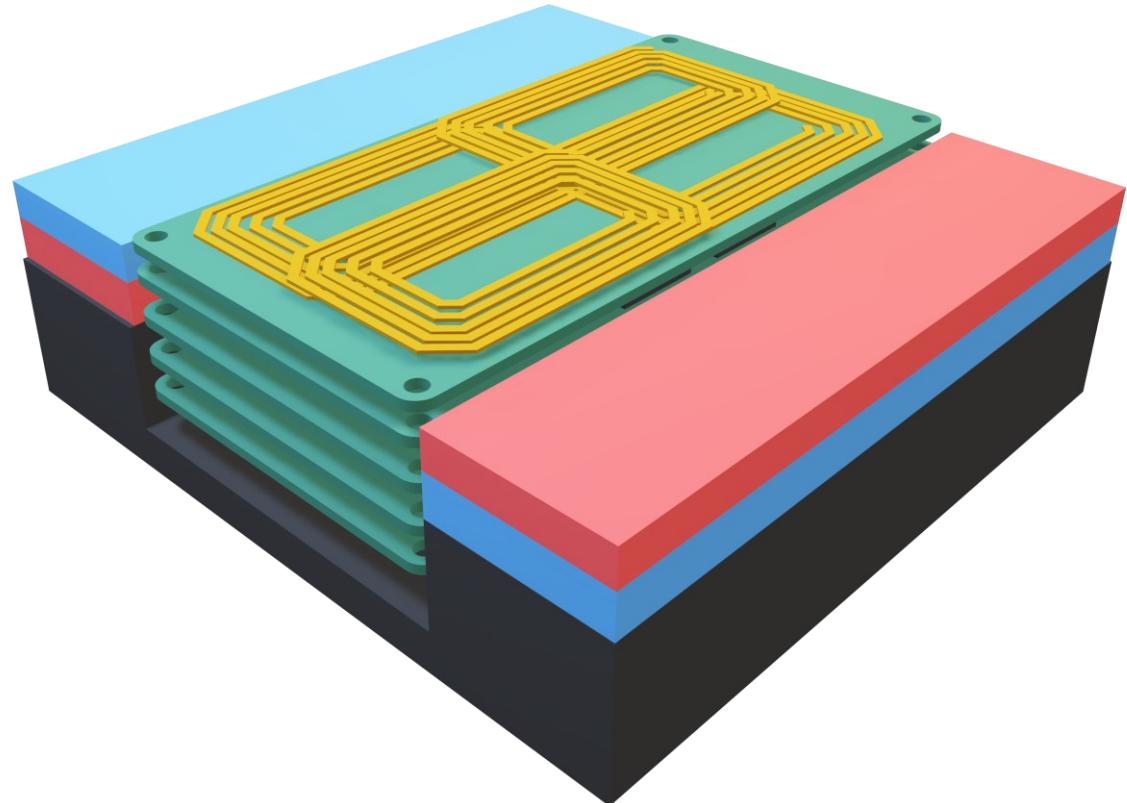


LPF Board

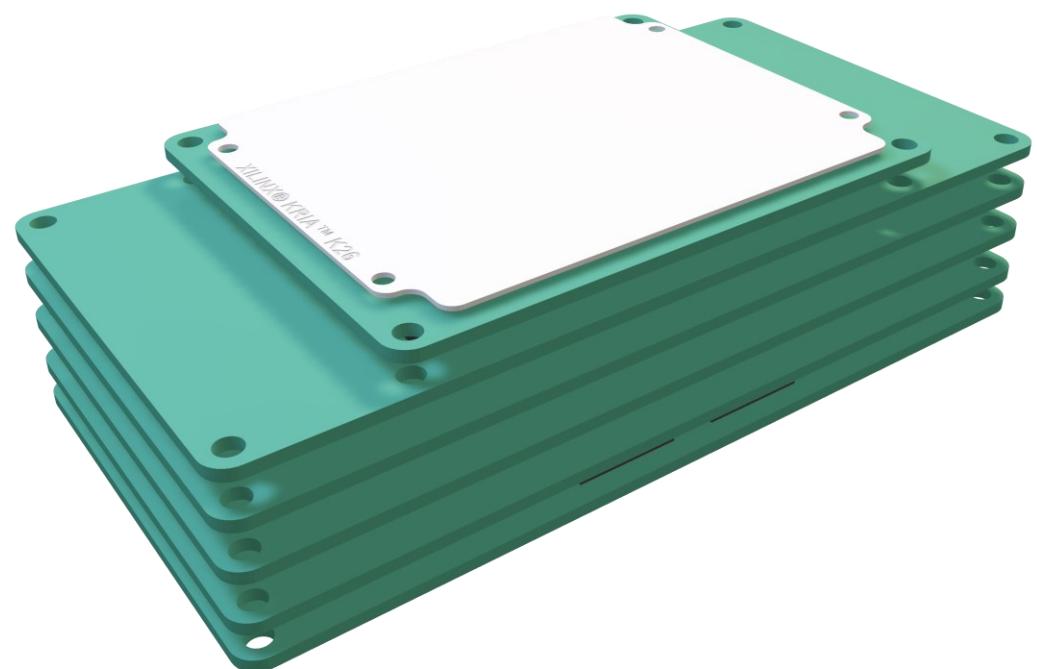
Disadvantages:

- Few GPIO for use (44)
- DAC introduces additional routing complexity and design redundancy

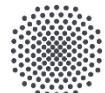




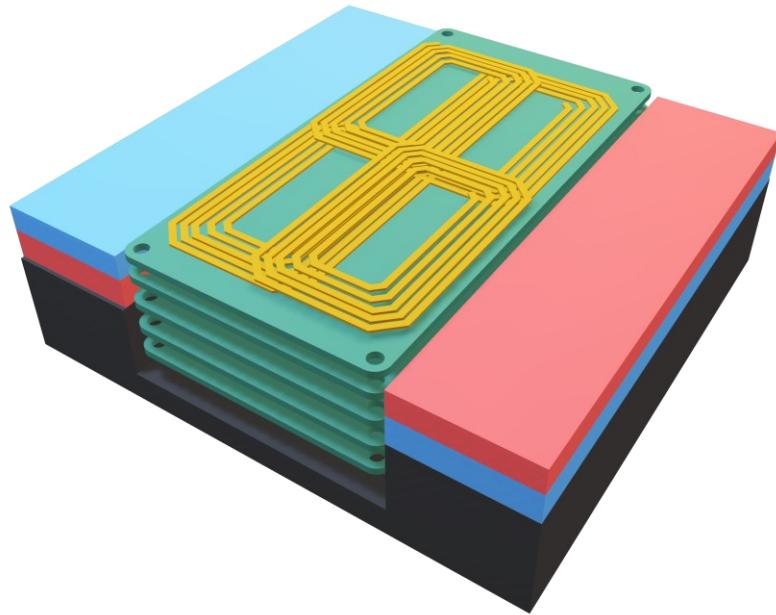
Full Design with Magnet and Iron Yoke



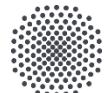
FPGA and PCB Stack Only

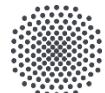
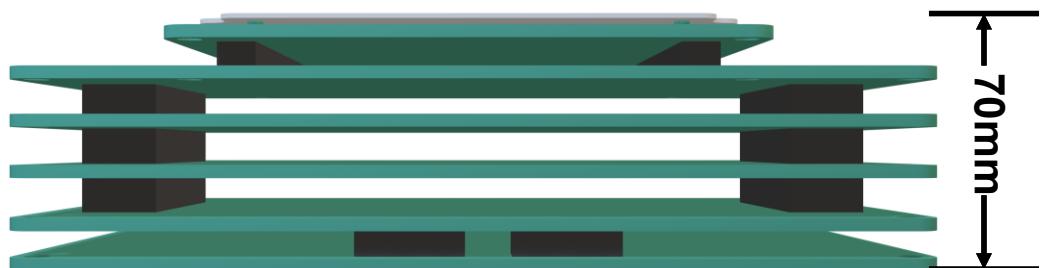
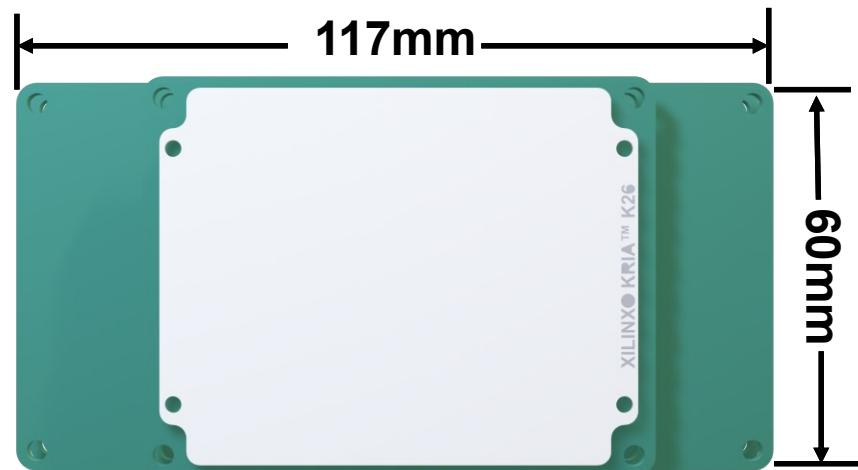
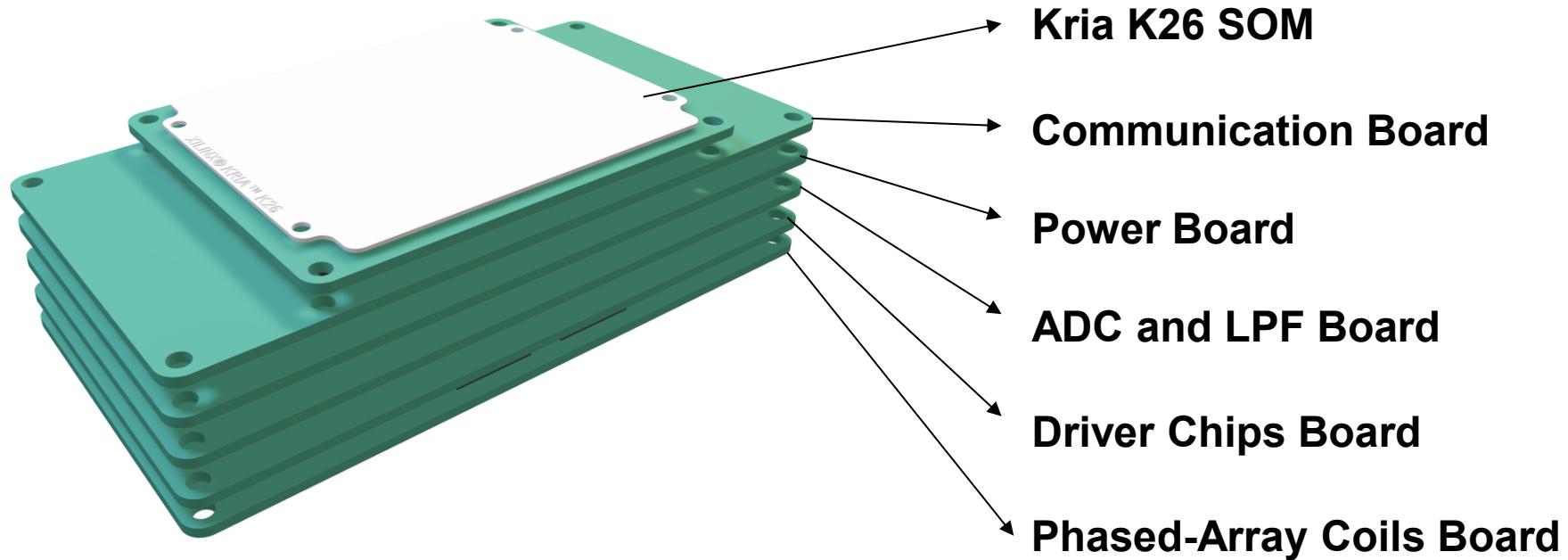


- Design Highlights

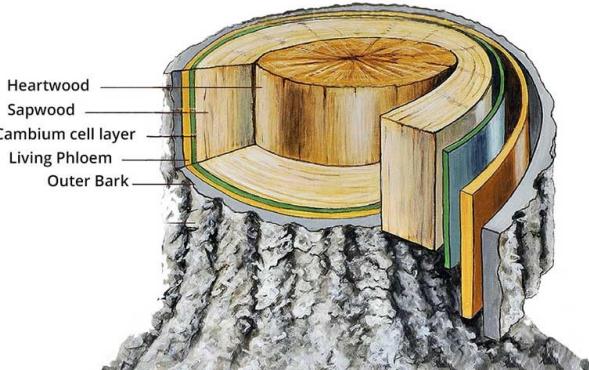


1. Large Scan Region and Strong B_1 Field
2. Single-Sided Magnet for Non-Invasive Measurement
3. Four Independently Controlled Channels
4. Compact and Portable Design

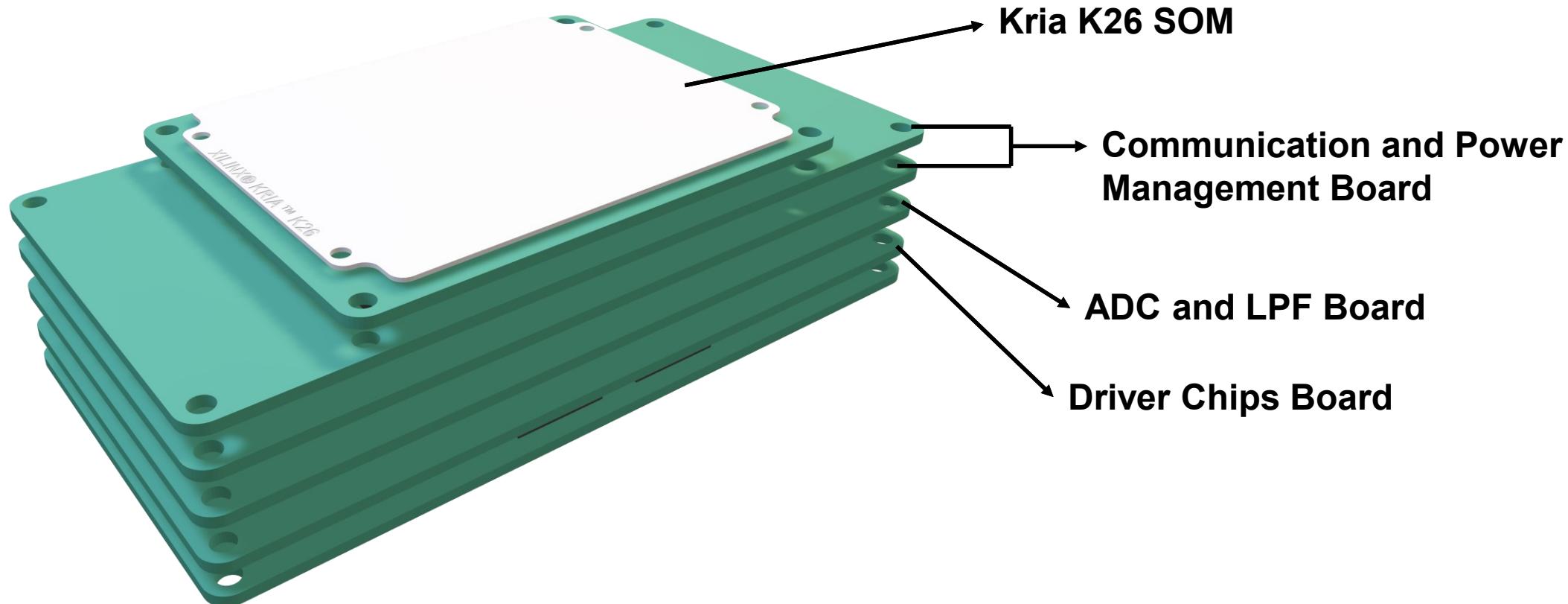




- Applications Prospects

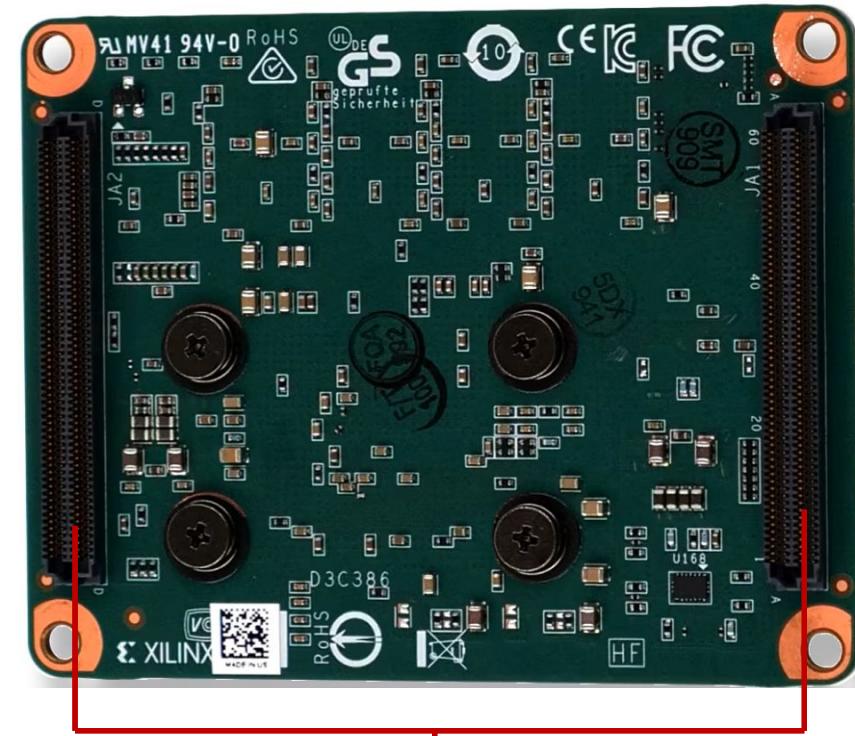
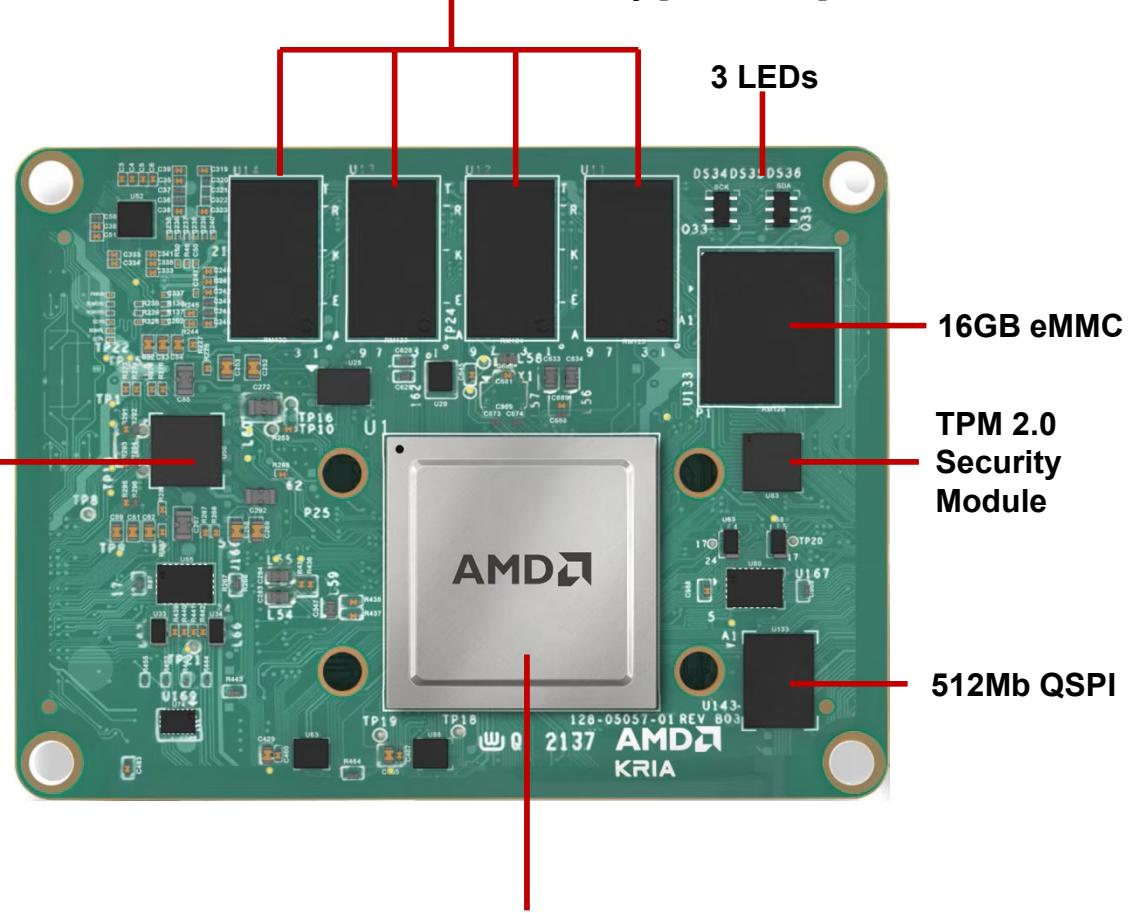


Material State	Typical T_2 Range	Required P90 Duration
Solid / Porous Materials	0.1 – 3 ms	$\leq 3\text{--}5 \mu\text{s}$
Semi-Solid Materials	0.5 – 20 ms	$\leq 5\text{--}8 \mu\text{s}$
Liquids	100 ms – 2 s	$\leq 8\text{--}12 \mu\text{s}$

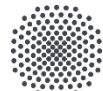


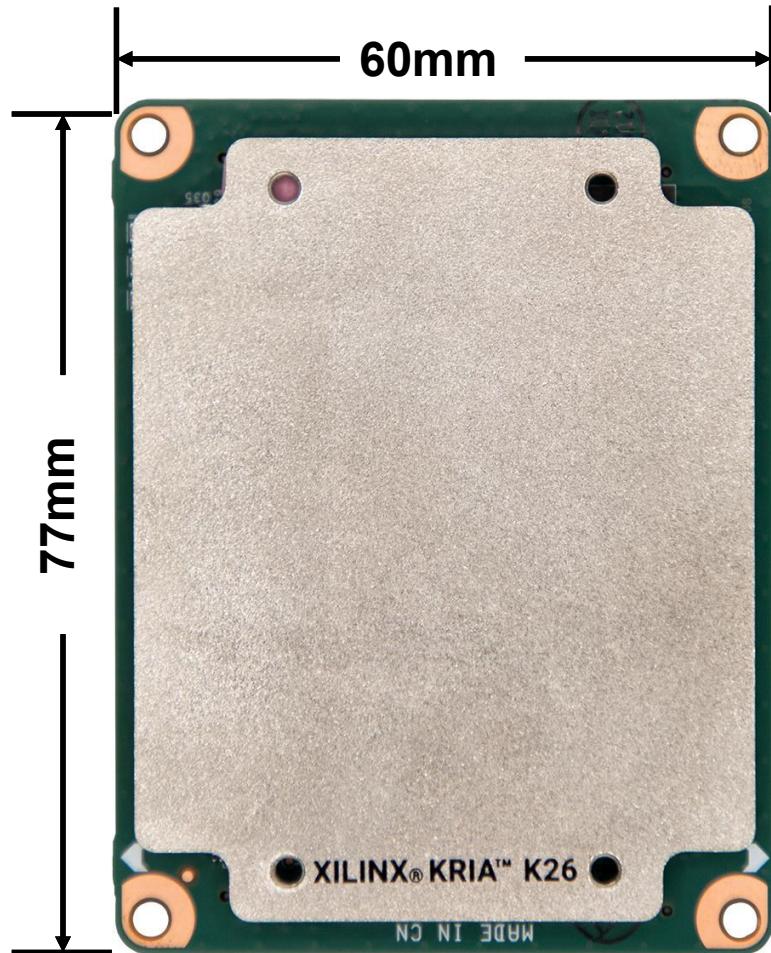
- Kria K26 SOM

4GB 64 Bit Wide DDR4 Memory [Non- ECC]

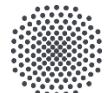


Two 240 Pin Connectors with Access to User-Configurable I/O

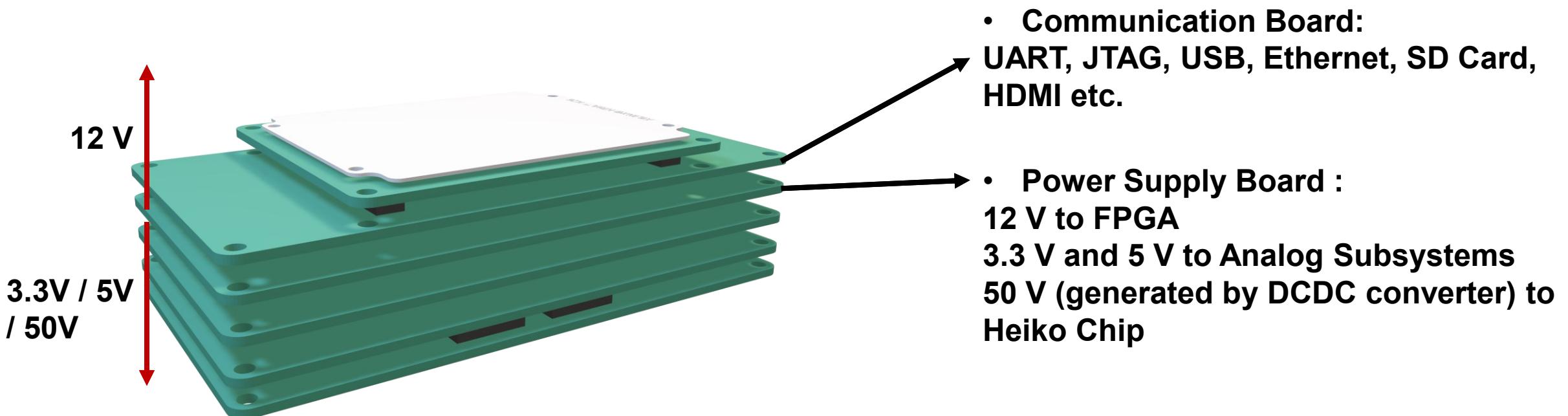




- Supports embedded Linux (GNOME)
- Fully stand-alone operation, client-free
- Provides more accessible GPIO interface (178)
- Custom carrier board design reduces overall system size and improves integration

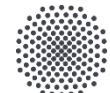
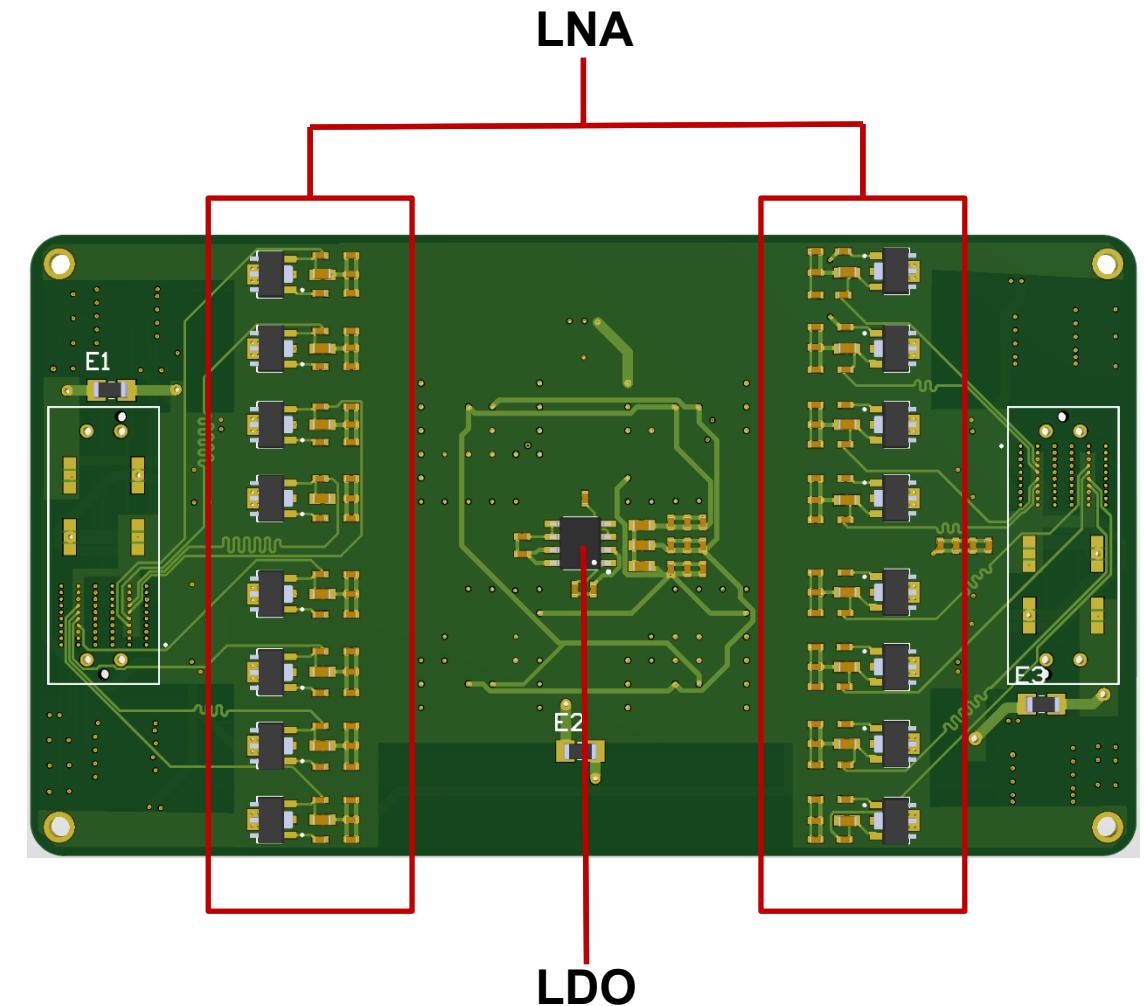
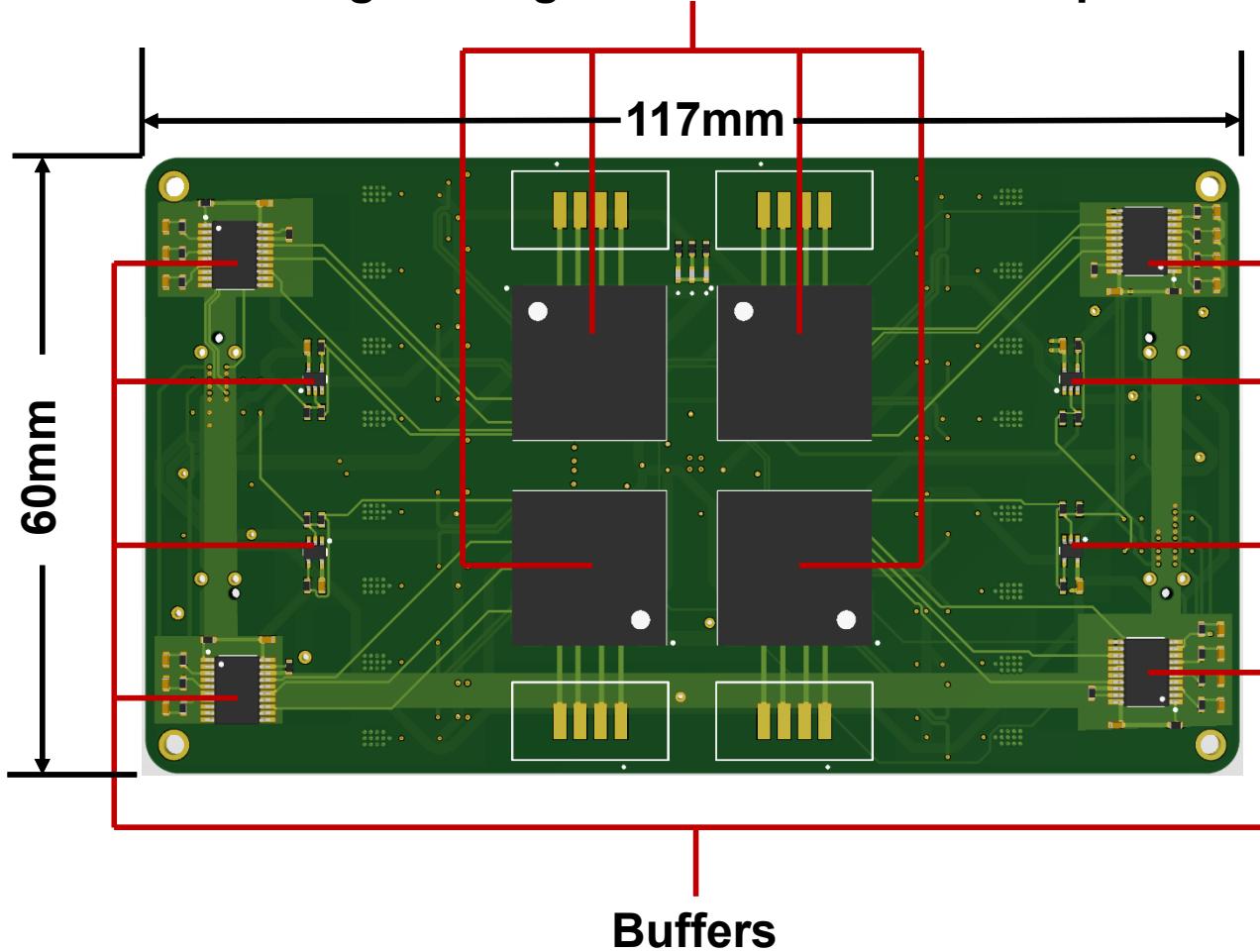


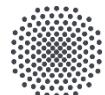
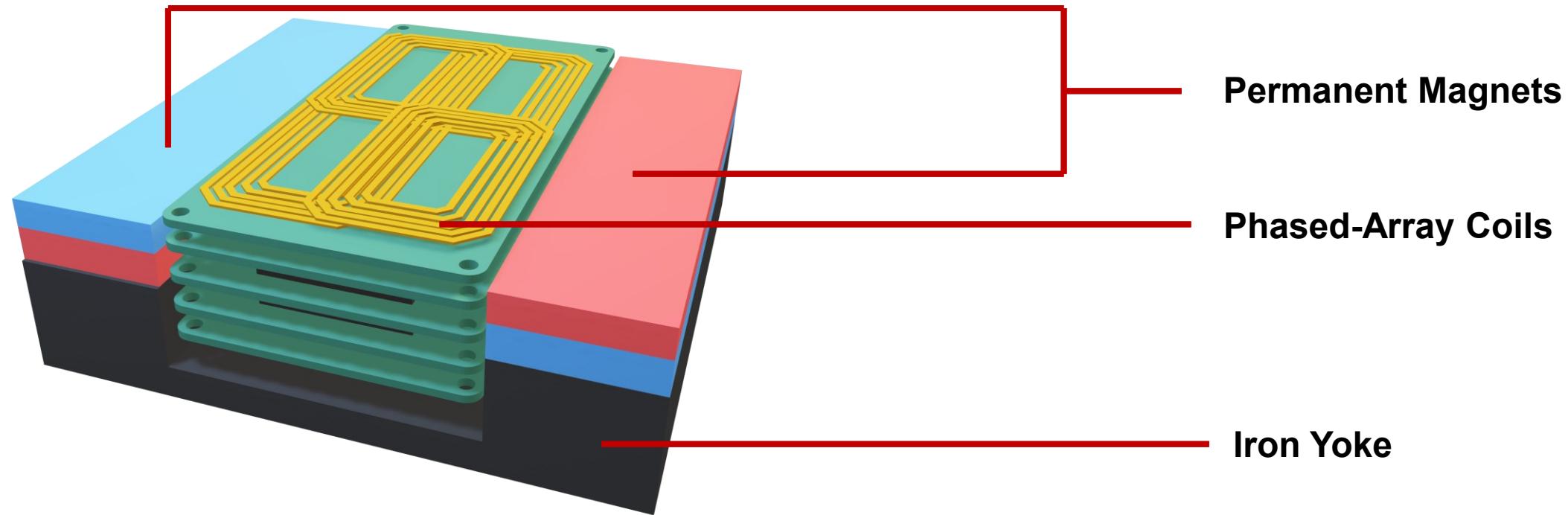
- Communication and Power Management Module



- Analog and Driver Circuit

High Voltage NMR Transceiver Chip





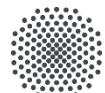
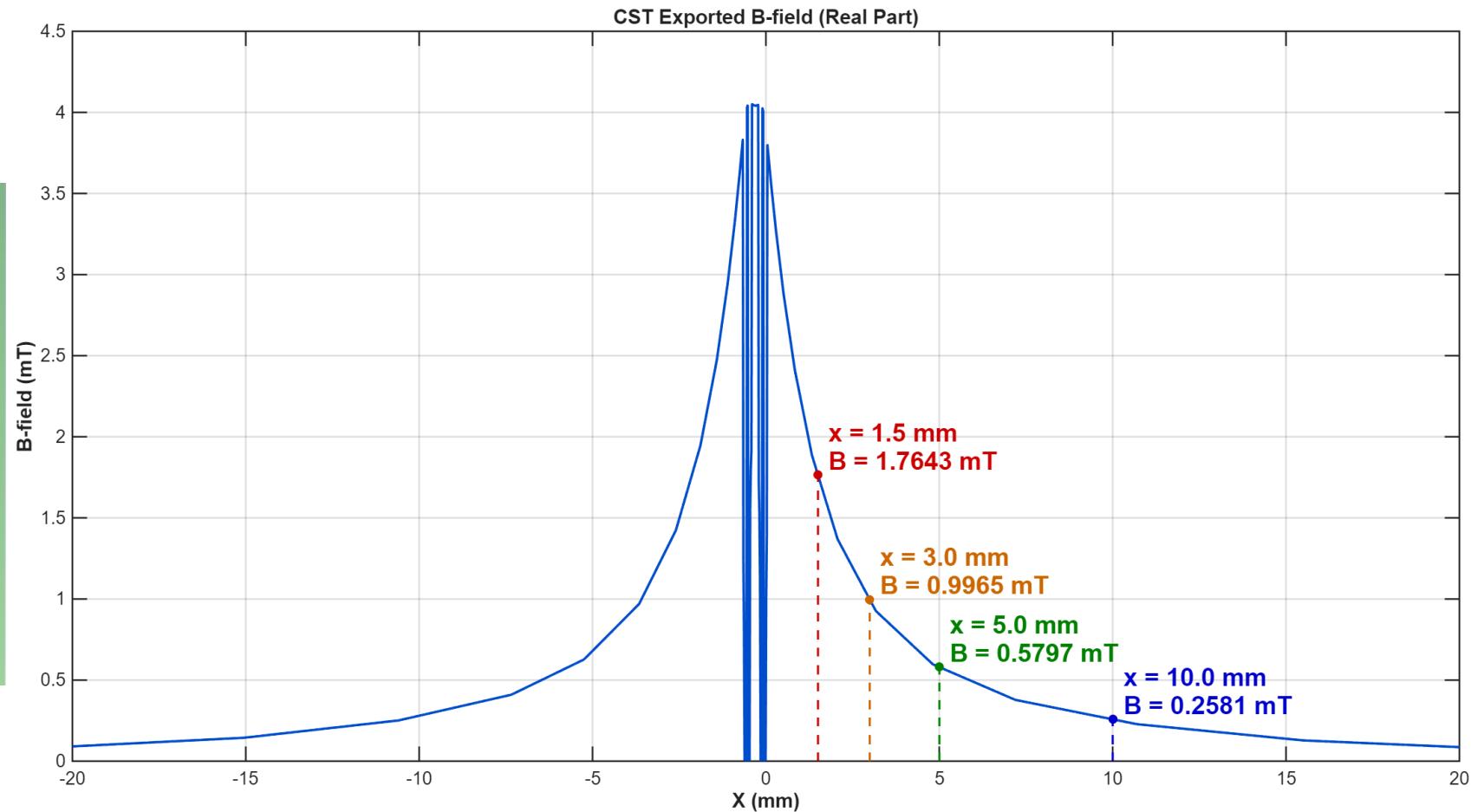
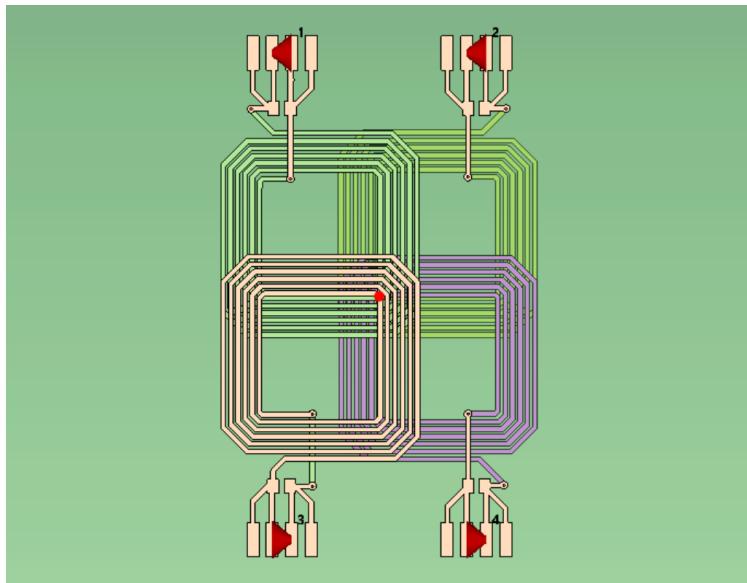
- Phased-Array Coil Assembly

Plan A: Outer diameter: 20 mm

Overlap area: 15%

Number of turns: 5

B = 1.16 mT at 5 mm (I = 2 A)



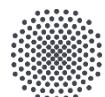
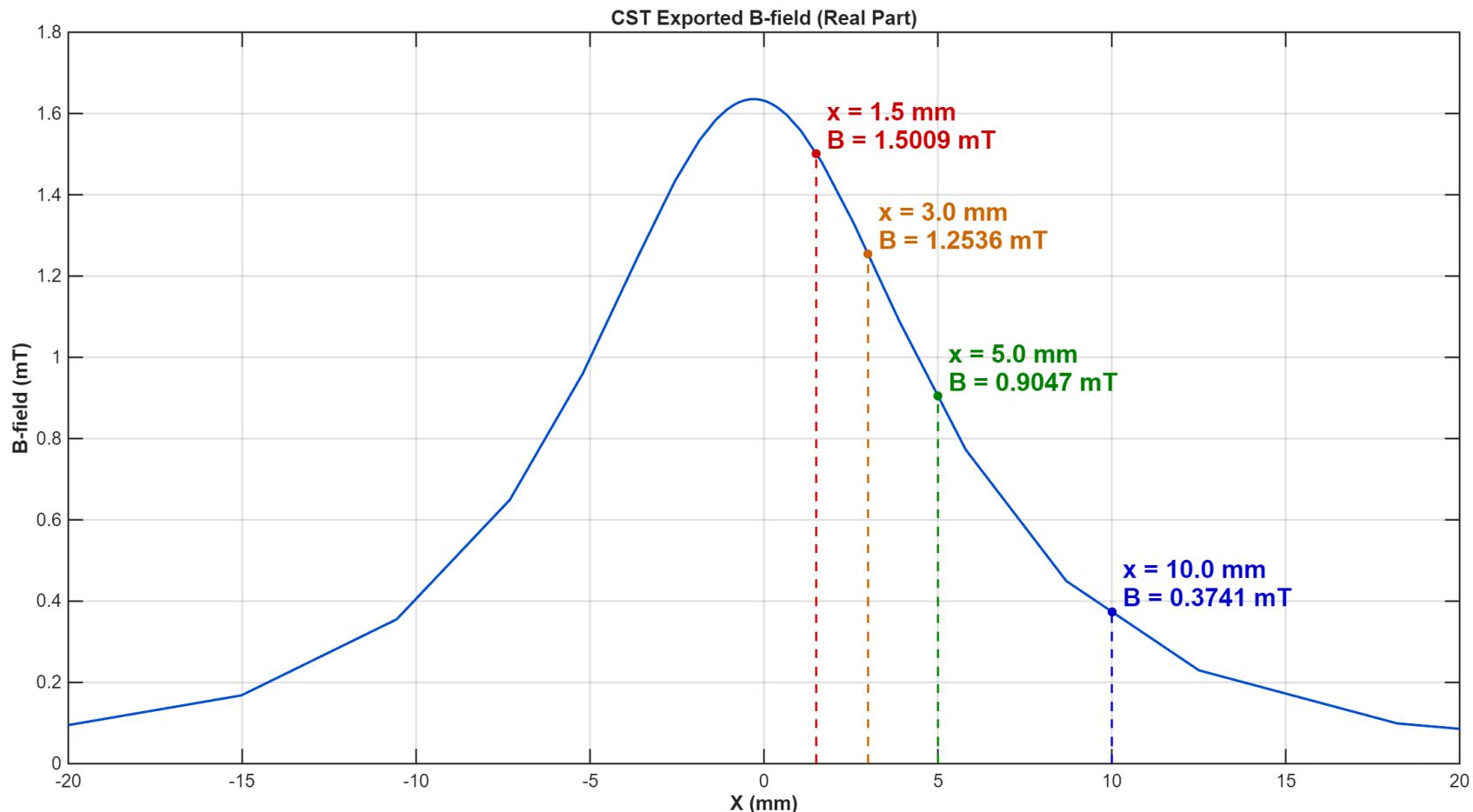
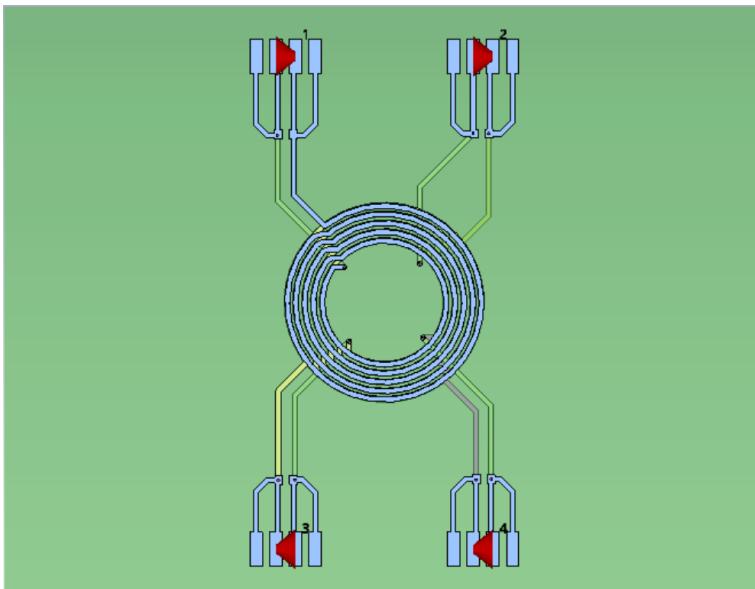
- Phased-Array Coil Assembly

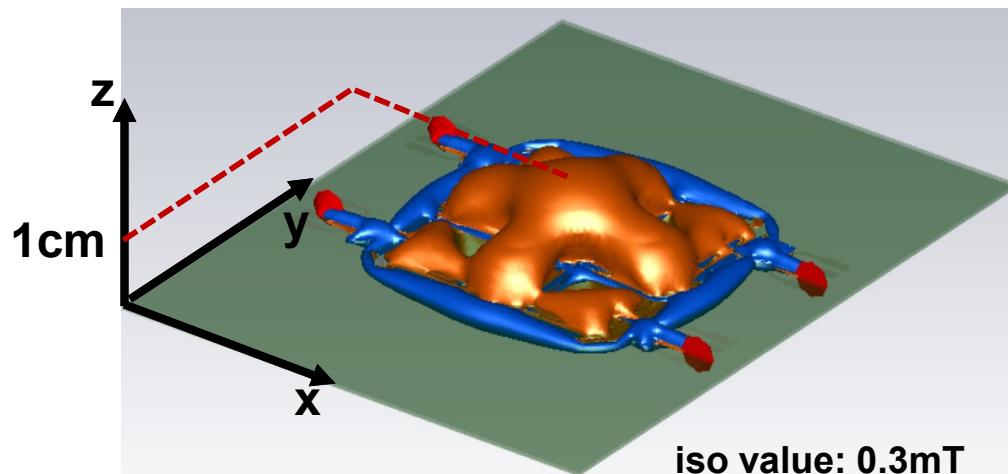
Plan B: Outer diameter: 20 mm

Overlap area: 100 %

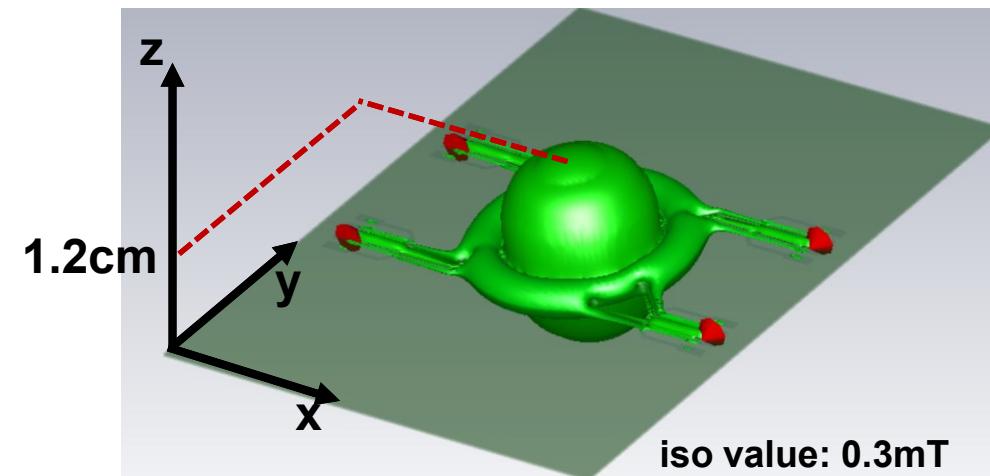
Number of turns: 5

B = 1.8 mT at 5 mm (I = 2 A)

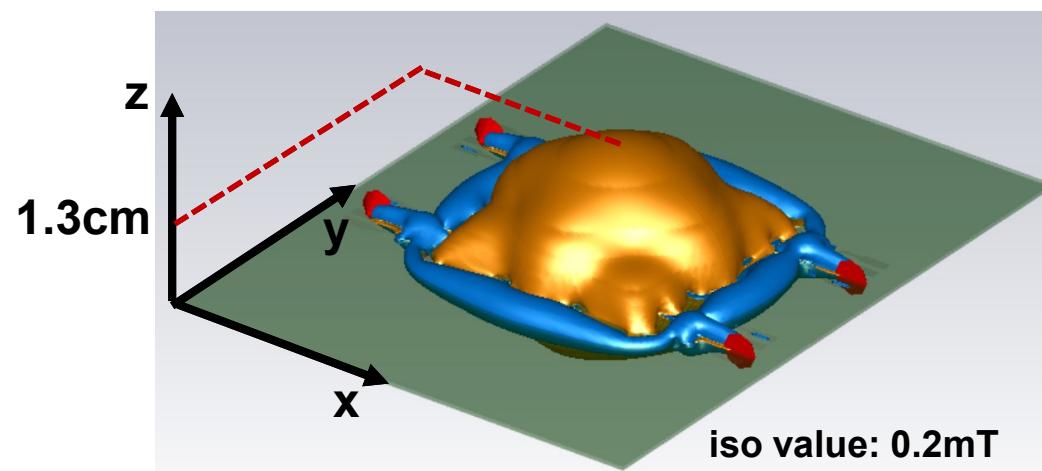




iso value: 0.3mT

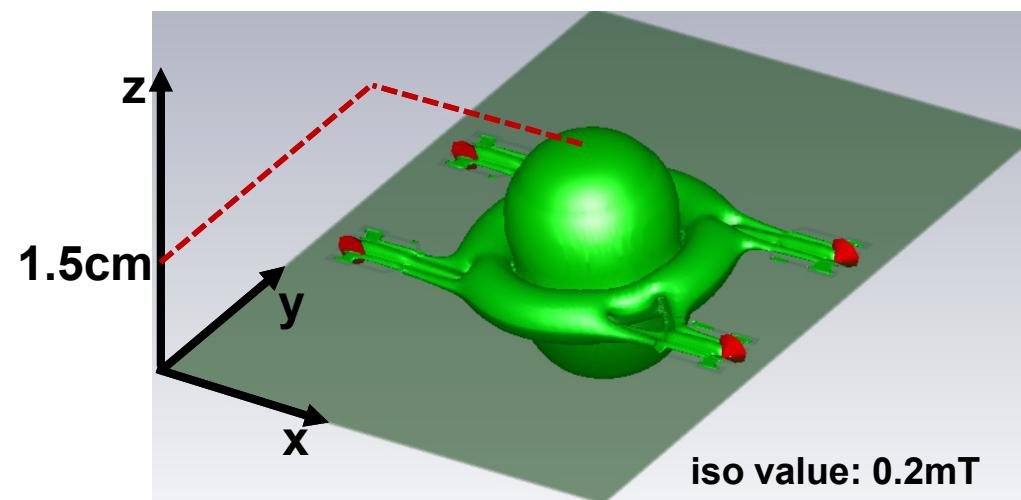


iso value: 0.3mT



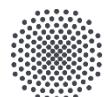
iso value: 0.2mT

Plan A

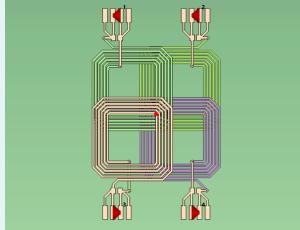
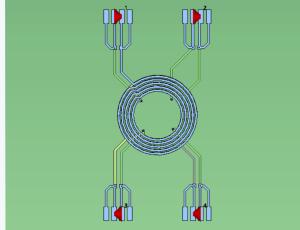


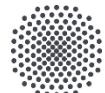
iso value: 0.2mT

Plan B

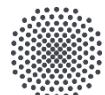
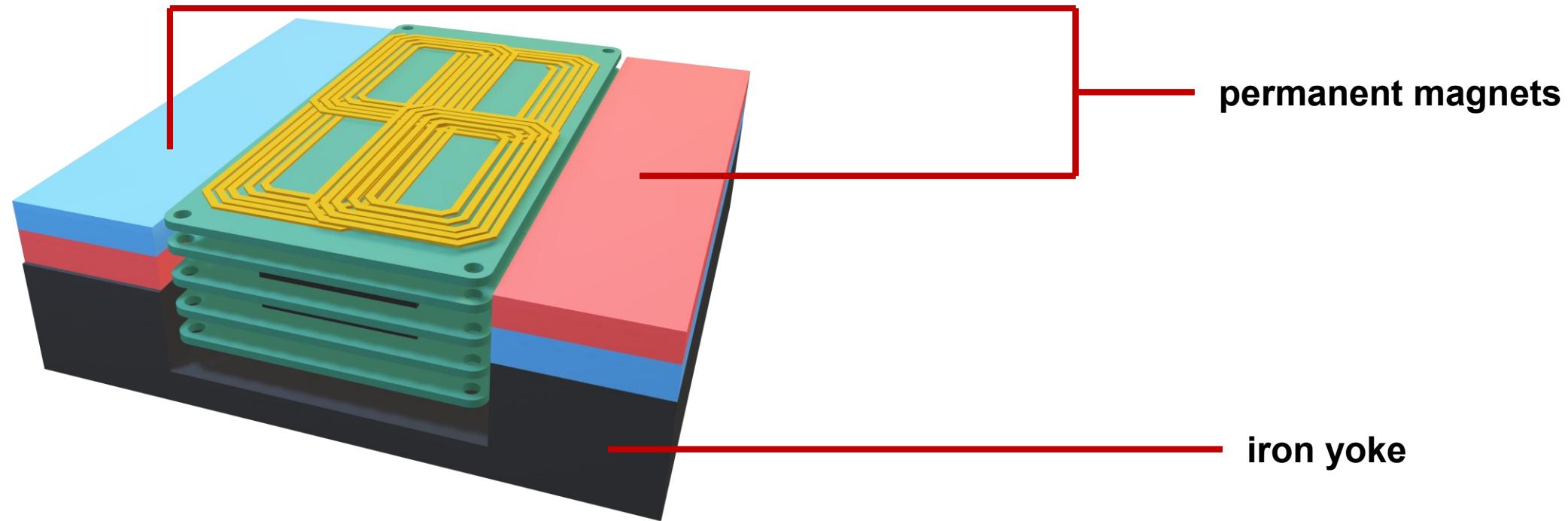


■ Comparation

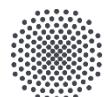
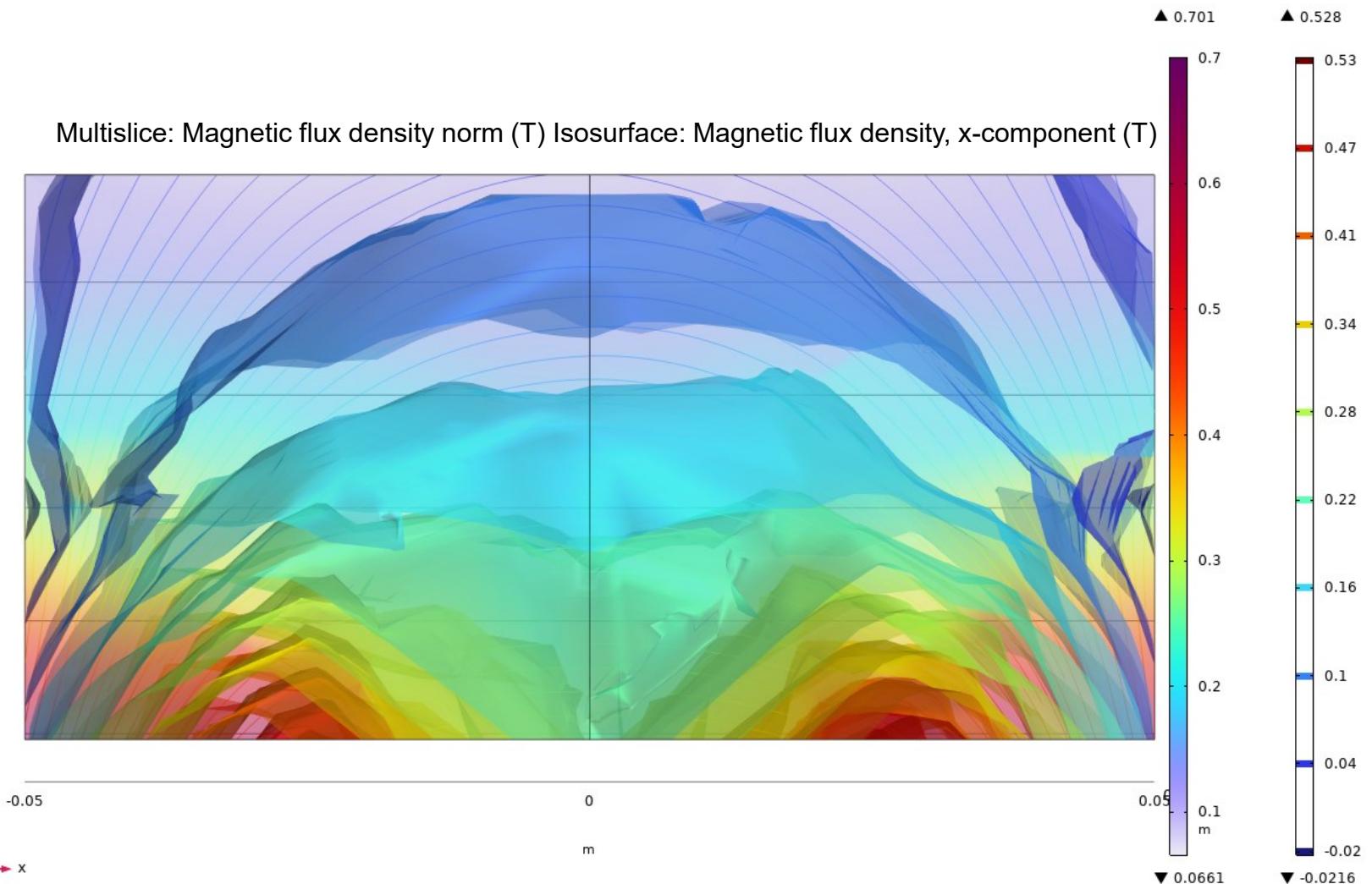
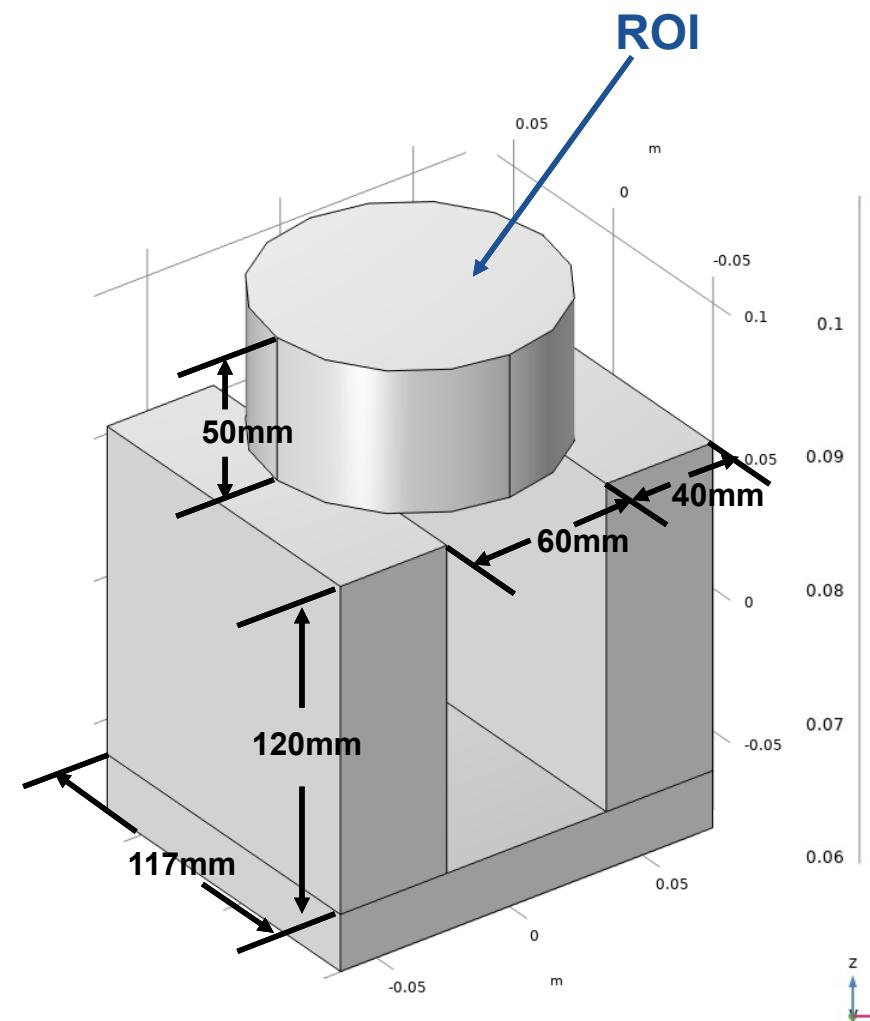
	Coil Size	B-field amplitude	Inductance (L)	P90 pulse width
Plan A	Diameter = 20 mm Length = 380mm 	1.5mm: 3.6mT 3.0mm: 2.0mT 5.0mm: 1.0mT 1.0cm: 0.6mT	1.04µH	1.63µs 2.94µs 5.88µs 9.80µs
Plan B	Diameter = 20mm Length = 270mm 	1.5mm: 3.0mT 3.0mm: 2.6mT 5.0mm: 2.0mT 1.0cm: 0.8mT	0.67µH	1.96µs 2.27µs 2.94µs 7.36µs

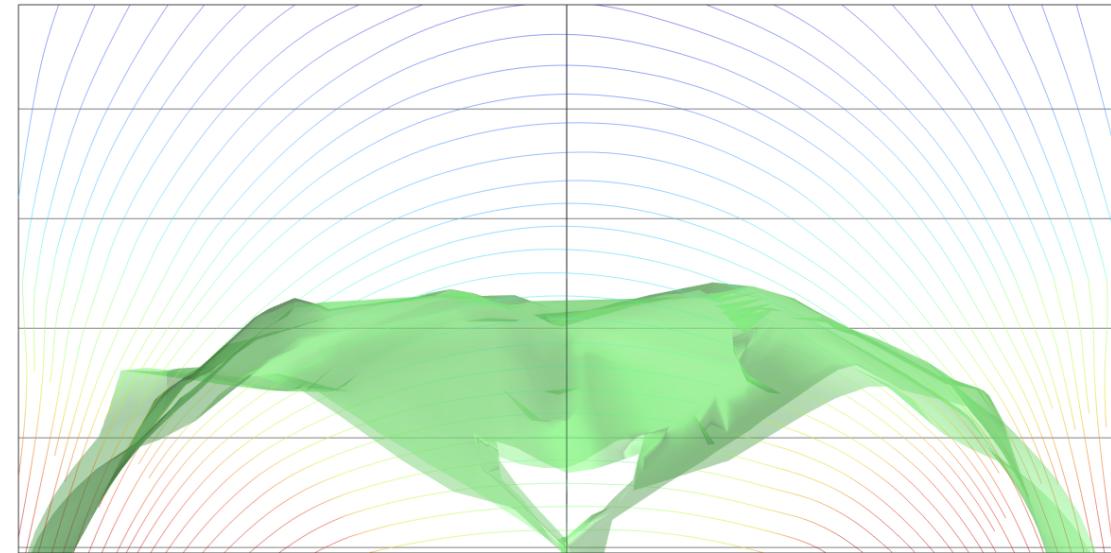


- Single-sided Magnet Design

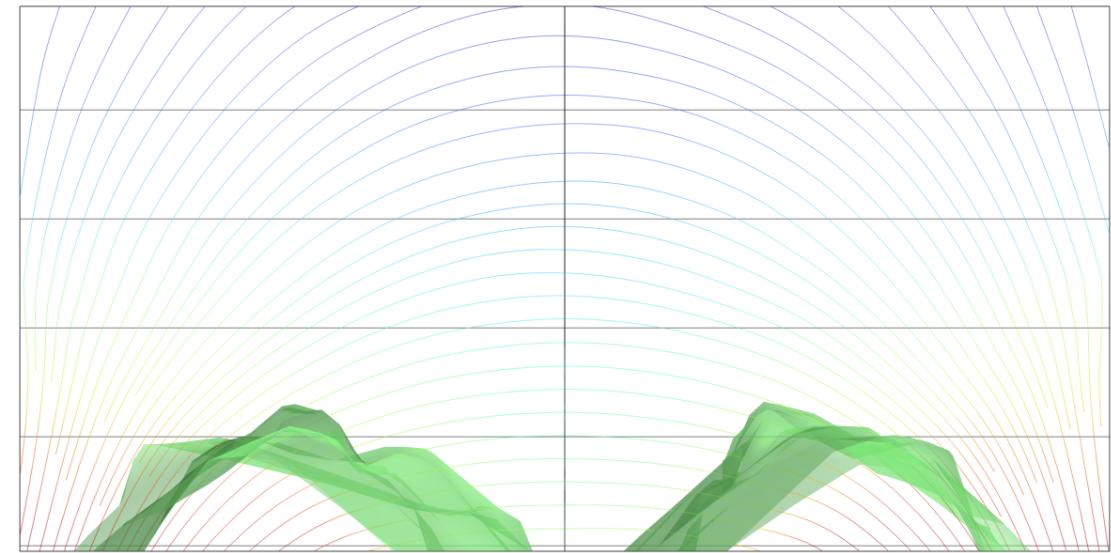


- COMSOL Assembly

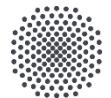




0.2T



0.3T



- Improvement Plan

Dimension: 40 x 40 x 20 mm

Inclination Angle : 30°

