

Flexible Multi-Turn Multi-Gap Coaxial RF Coils (MTMG-CCs) for 3 and 7 Tesla MRI

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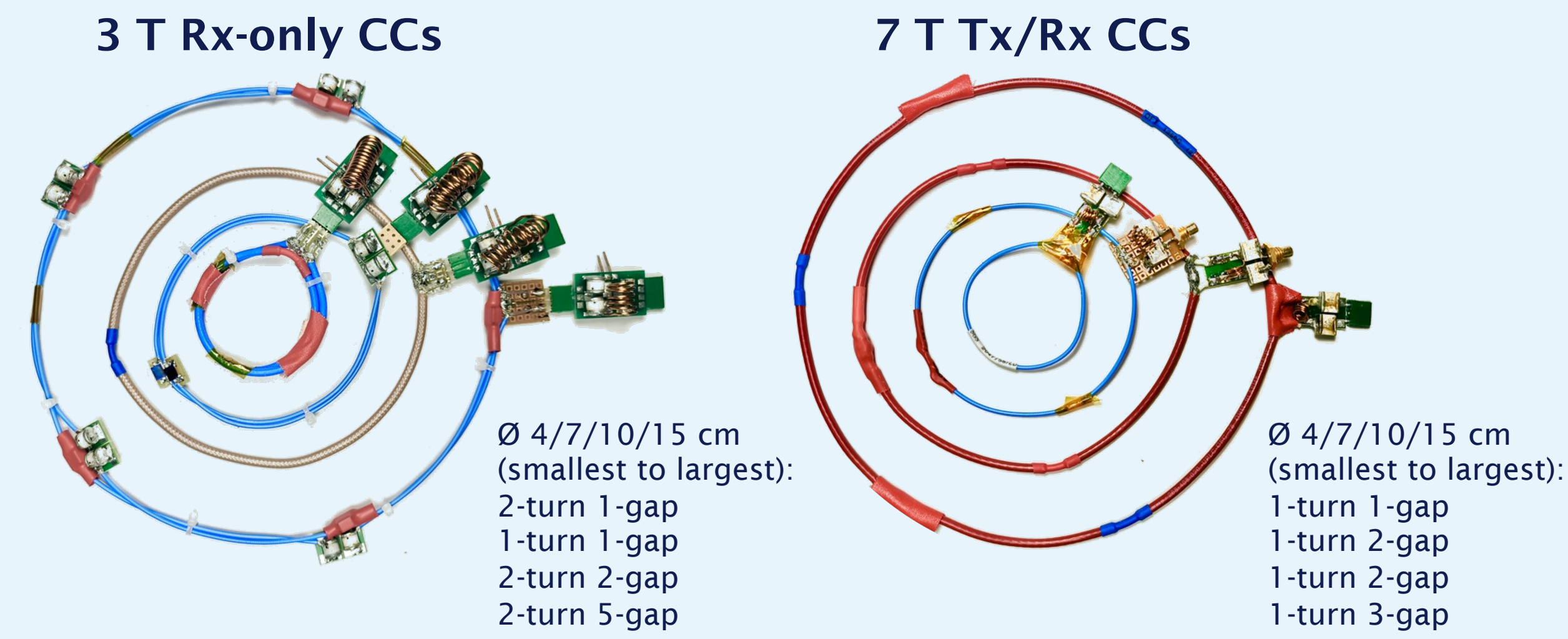
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Objective

- Design RF coils that are
- highly flexible
 - lightweight
 - size-adapted and form-fitting
 - robust upon bending

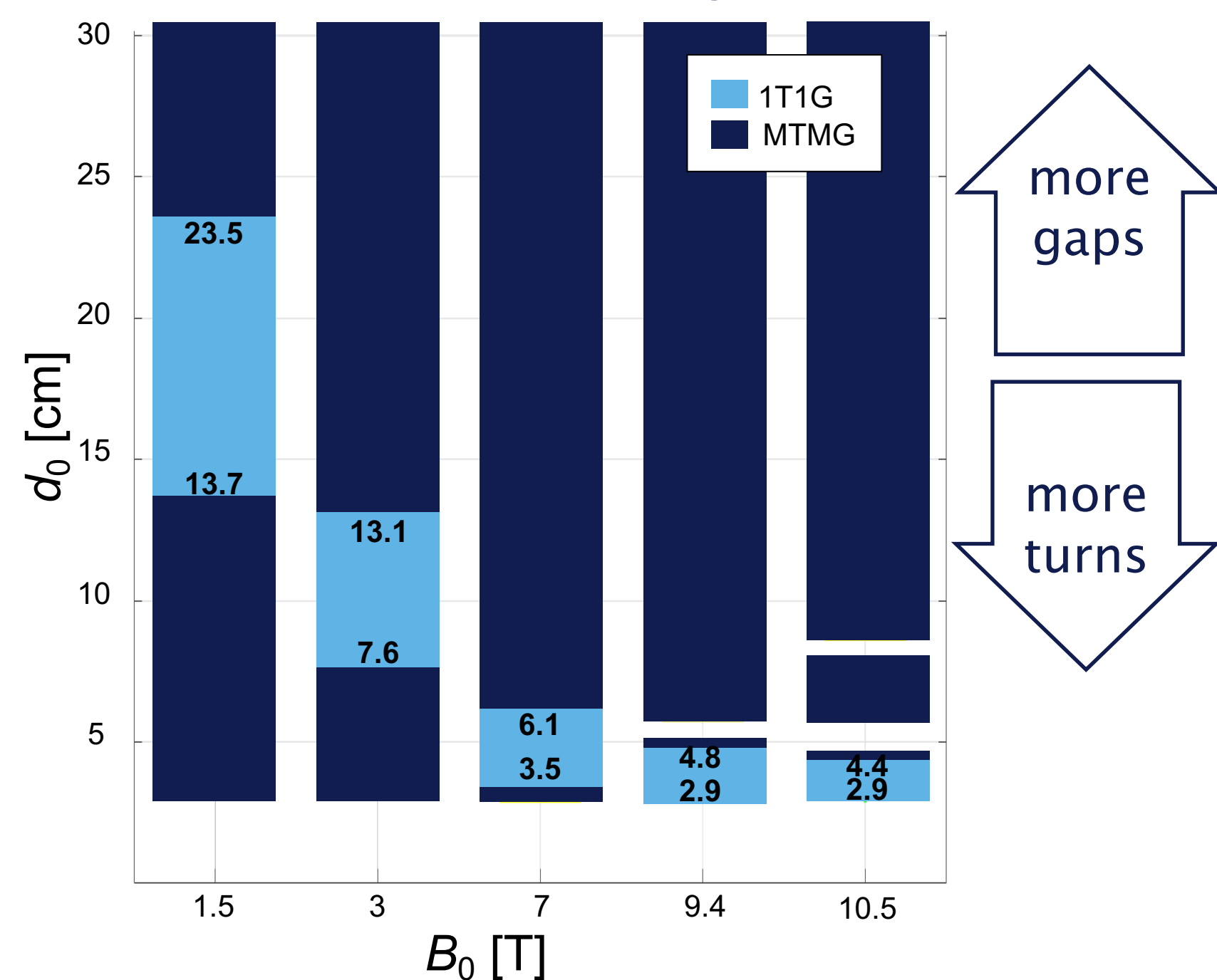
Overcome size restriction of single-turn single-gap¹ coaxial coils² (CCs) by introducing multiple cable turns and/or gaps^{3,4} (in the inner and outer coaxial conductor)



Materials and Methods

Design concept	Equivalent circuit	Analytical calculations	Electromagnetic simulations	RF coil fabrication	Experimental validation
Number and position of turns and gaps	derivation of resonance condition ⁵	MATLAB: calculate resonance frequency f_0 and achievable coil size range ⁶	CST (FEM solver): surface current behavior specific absorption rate (SAR)	Rx-only @ 3 T Tx/Rx @ 7 T } coil Ø 4/7/10/15 cm • 8 coaxial coils (CCs) – 5 coaxial cable types – max. 2 turns, max. 5 gaps • 8 standard copper wire coils (SCs)	bench measurements & MR experiments @ 3 T + @ 7 T in flat and bent coil position • active detuning reliability (3 T) • transmit efficiency (7 T) • SNR performance (3 T + 7 T)

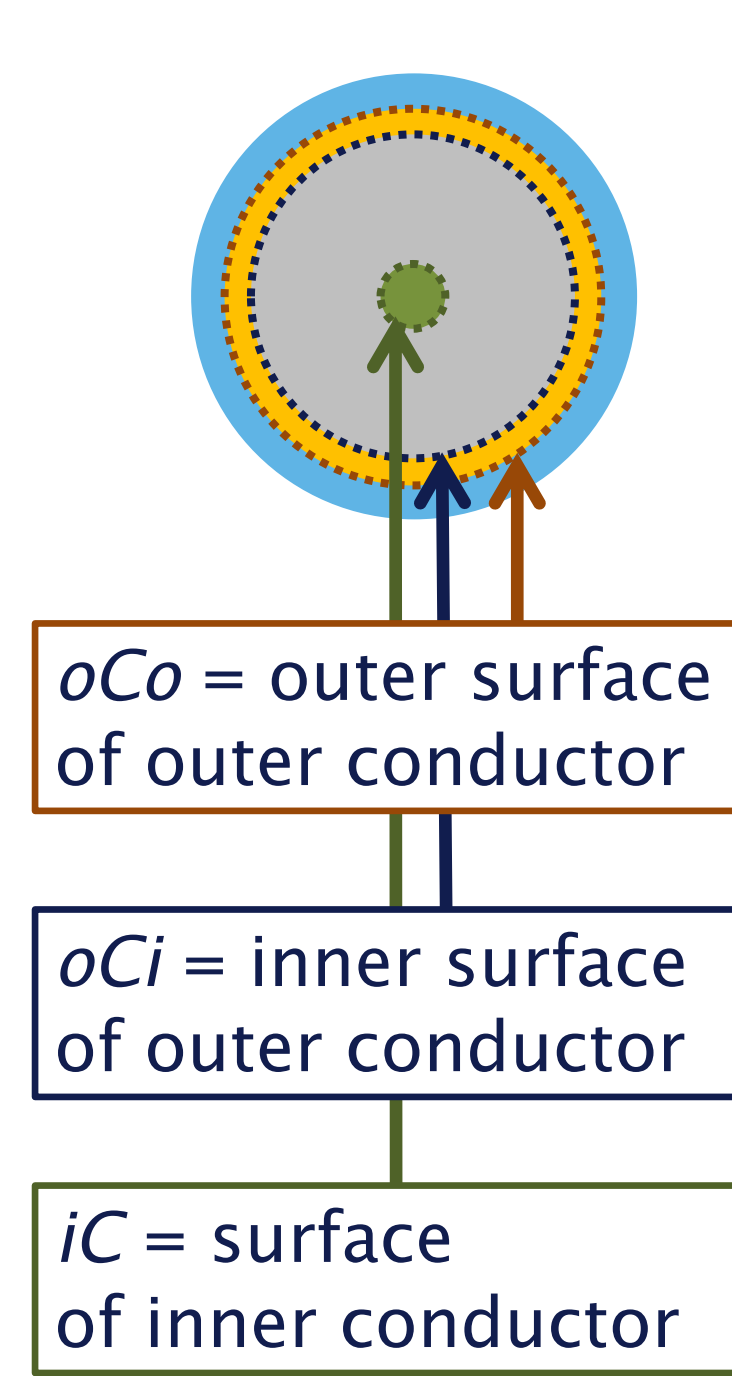
Achievable coil size range for ¹H MRI



Fabricated coaxial coil sizes for 3 T and 7 T (potential application)

- 4 cm (skin, hand, wrist)
- 7 cm (elbow, ankle, breast)
- 10 cm (breast, head, knee)
- 15 cm (abdomen)

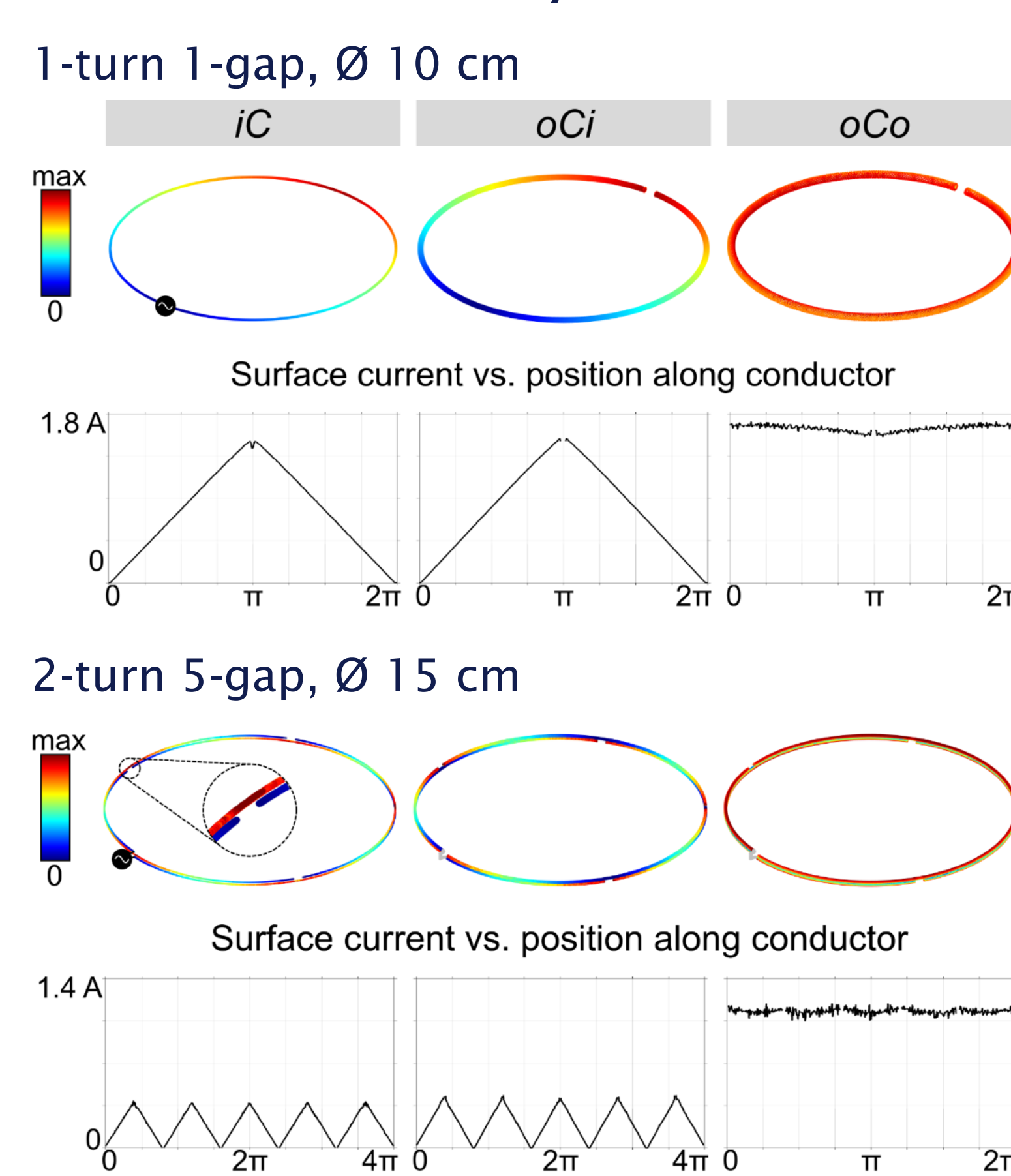
Coax cross section



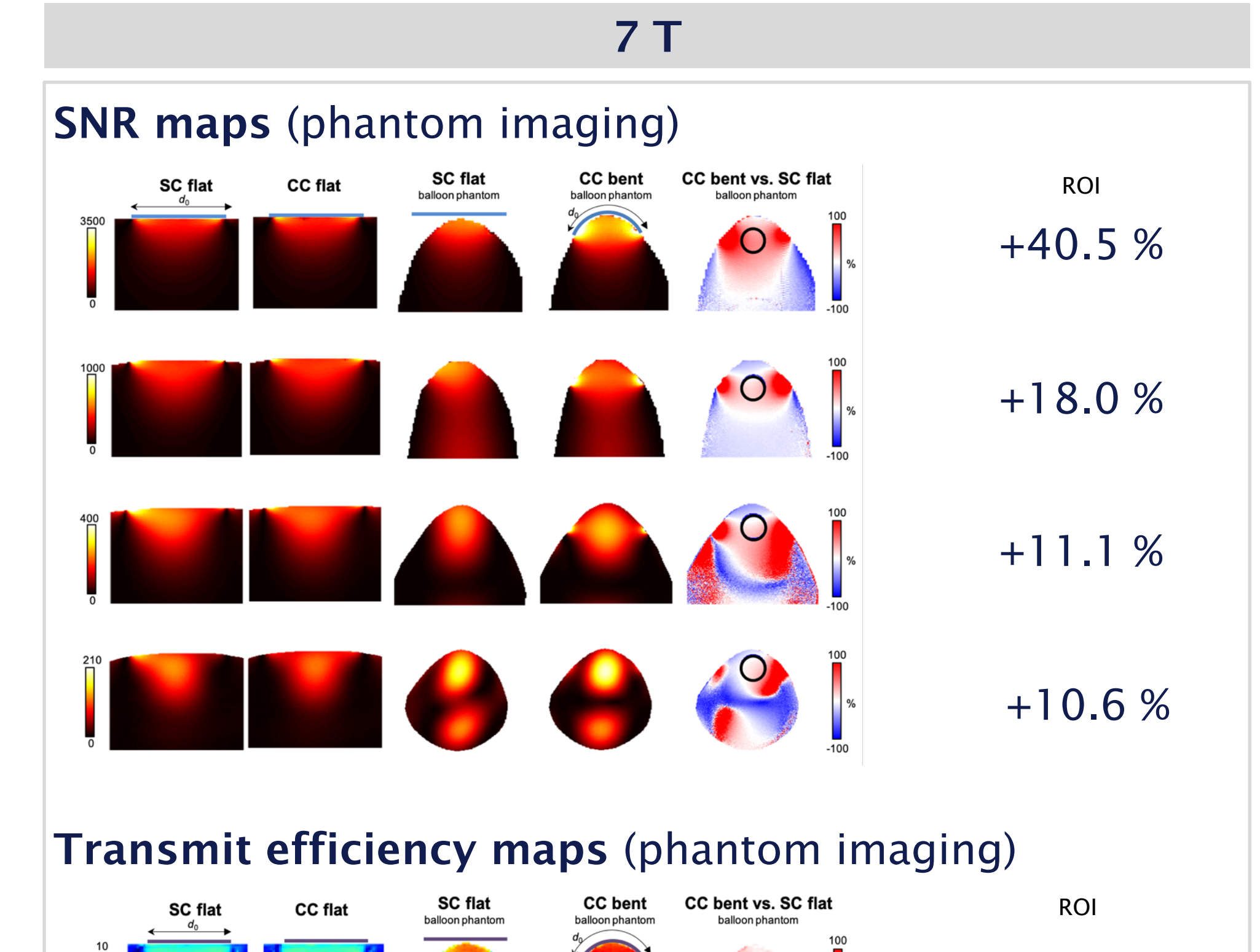
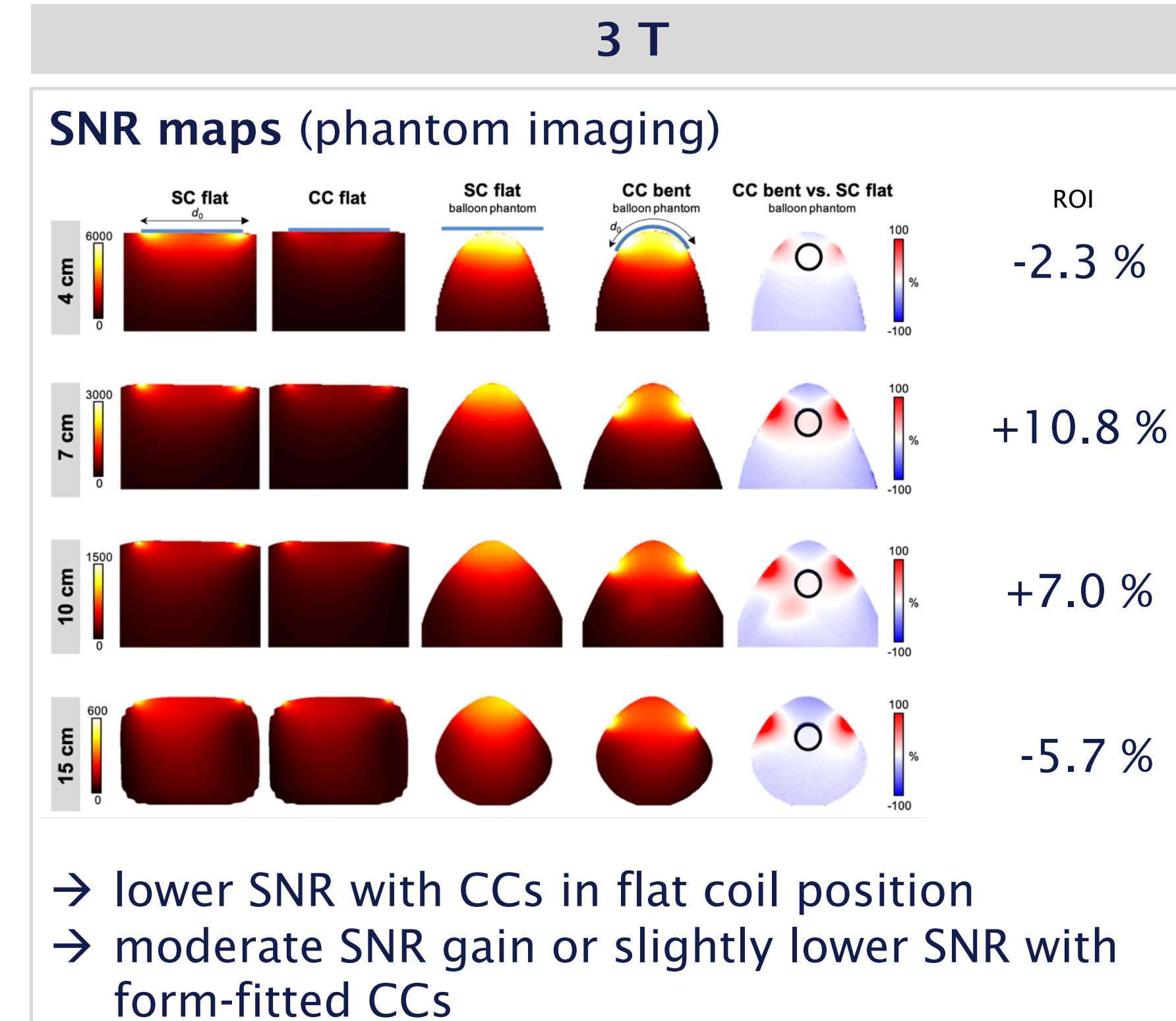
- cable jacket
- outer conductor
- dielectric
- inner conductor

→ surface current on *iC* is mirrored on *oCi* (maximum at every outer gap)
→ homogeneous current on *oCo* when CC is operated at self-resonance

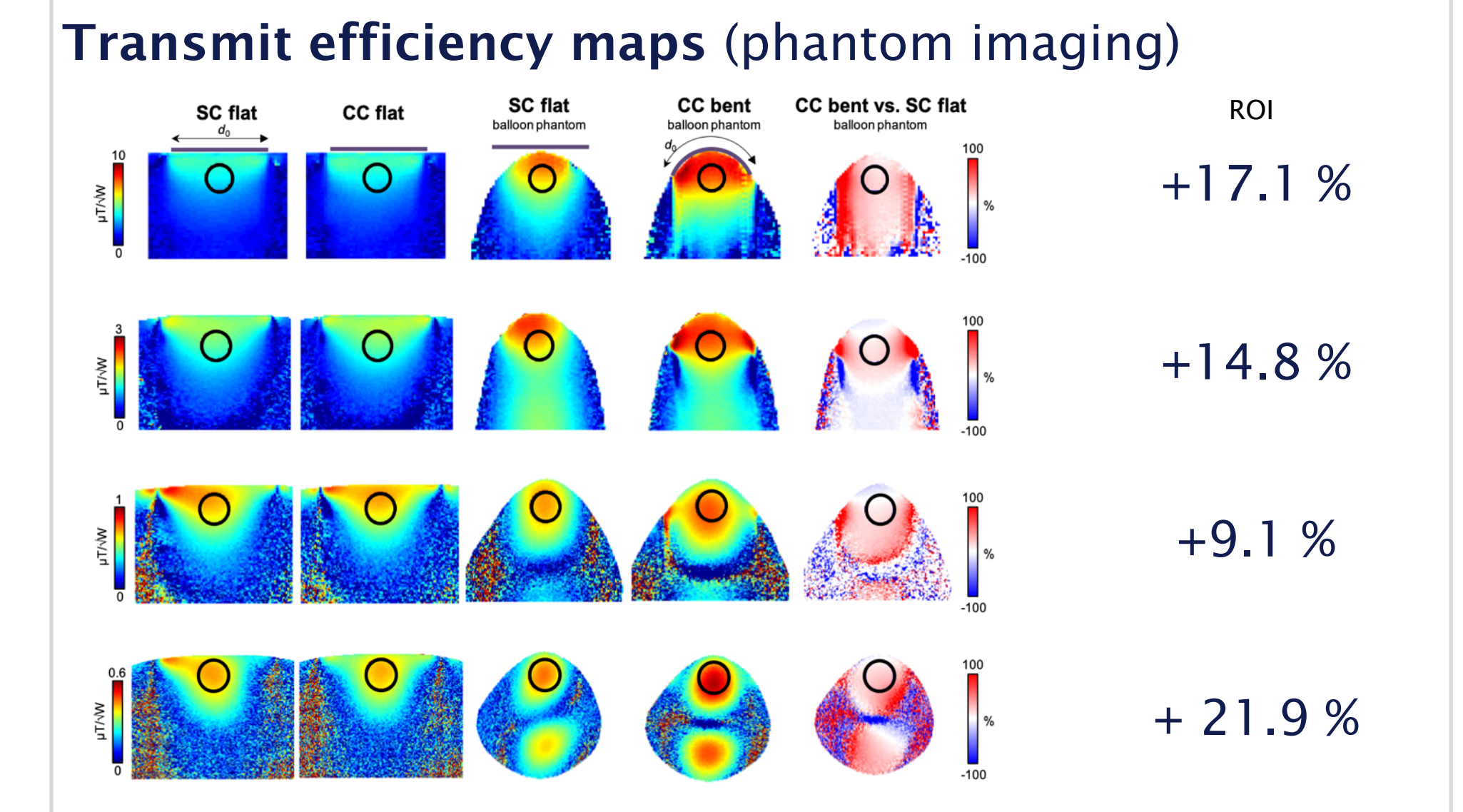
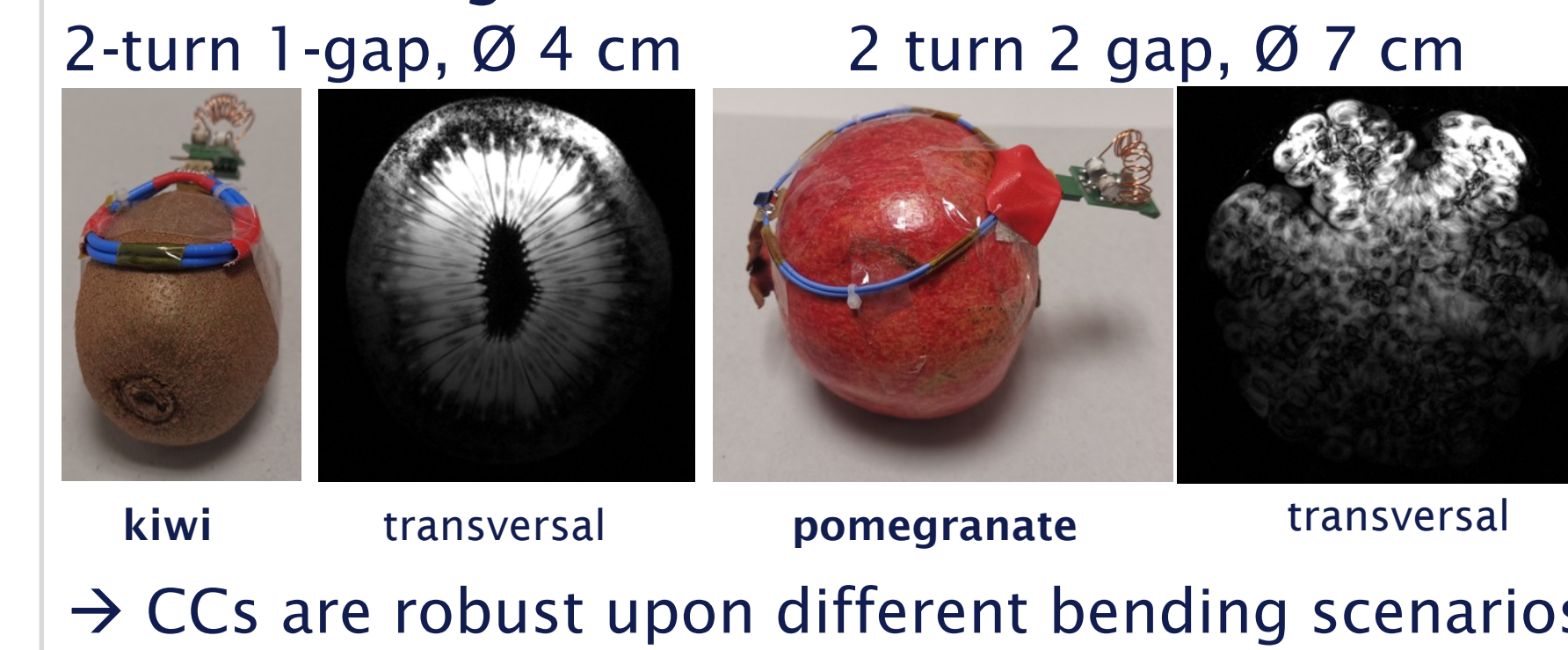
Surface current density simulation



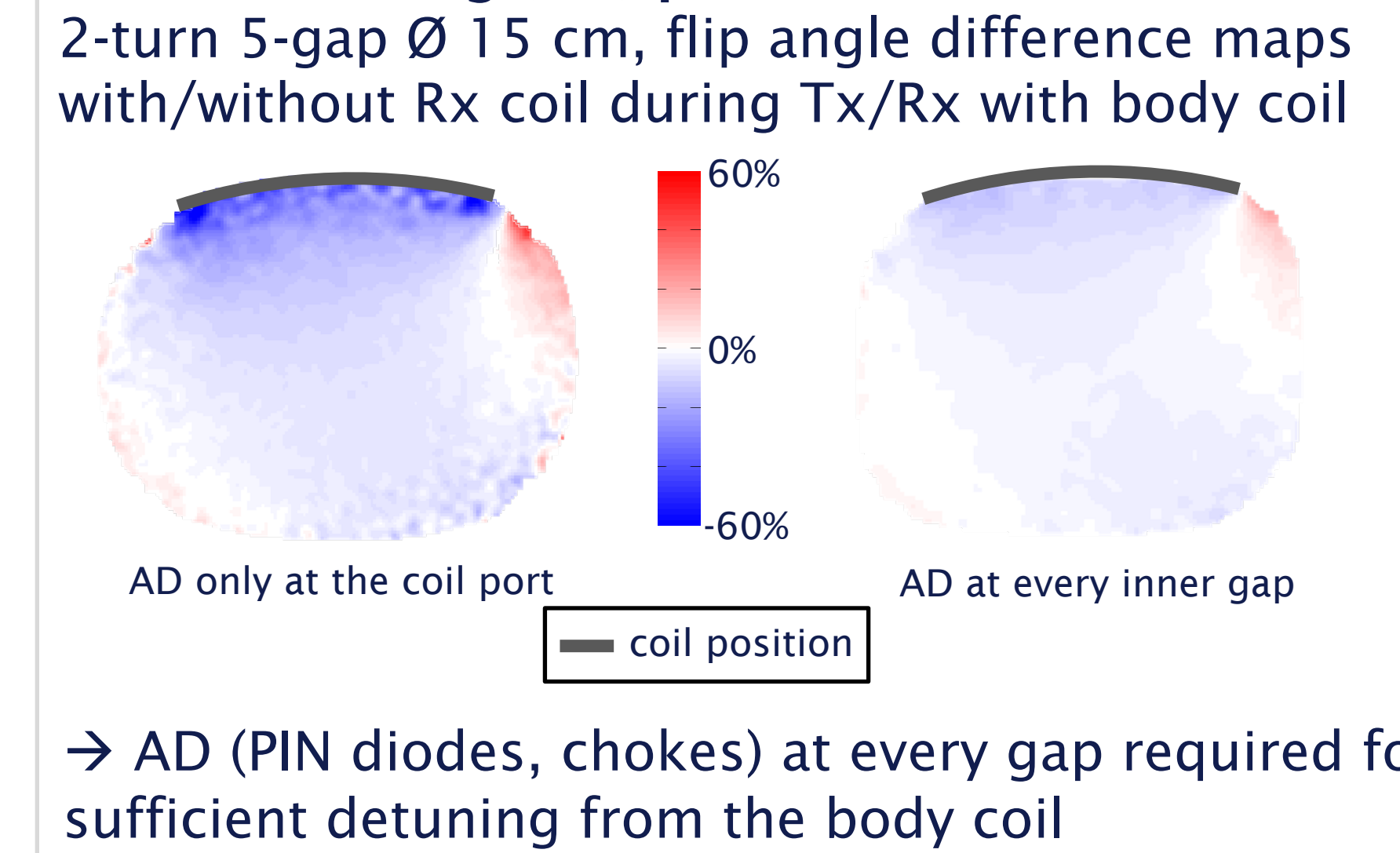
Results



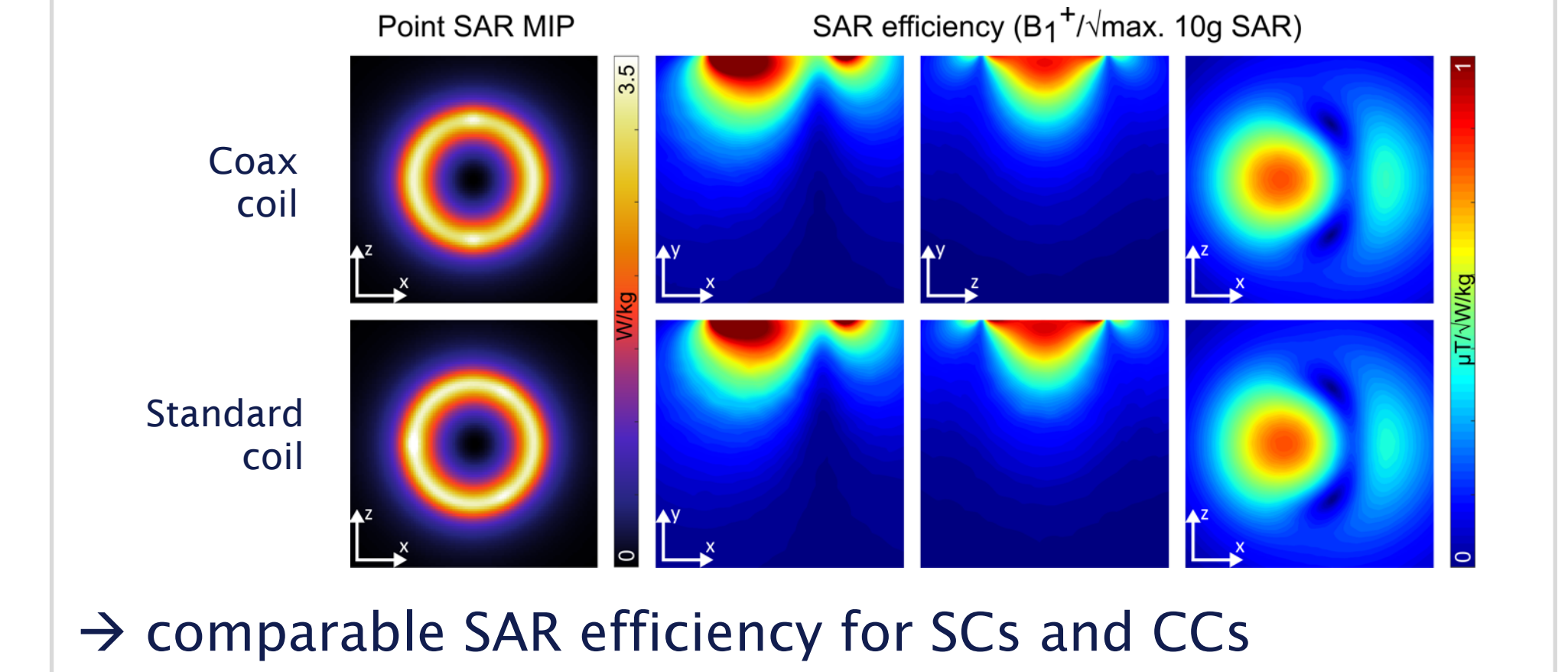
Fruit MR images



Active detuning (AD) performance



SAR simulation



Conclusion

- **Proof-of-concept** validated: multi-gap CCs (Ø 4-15 cm) in Rx-only mode at 3 T and Tx/Rx mode at 7 T
- **Multi-gap/-turn** principle → size-optimized RF coils for ideal FOV and SNR in various anatomical applications
- **Coaxial coil** principle → lightweight, high flexibility, patient comfort, “wearable” coils

References

- ¹ Zhang B, et al. *Nat Biomed Eng.* 2018;2(8):570-577
² Yang X, et al. US patent US9678180B2; 2017
³ Frass-Kriegl R, et al. *J Magn Reson.* 2016;273:65-72
⁴ Laistler E, Moser E. *Nature Biomed Eng* 2018;2(8):557-558
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