U.S. MAGNET
DEVELOPMENT
PROGRAM

Bi2212 SMCT coil development – design and practice coil fabrication

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U.S. MDP Collaboration Meeting (CM7)

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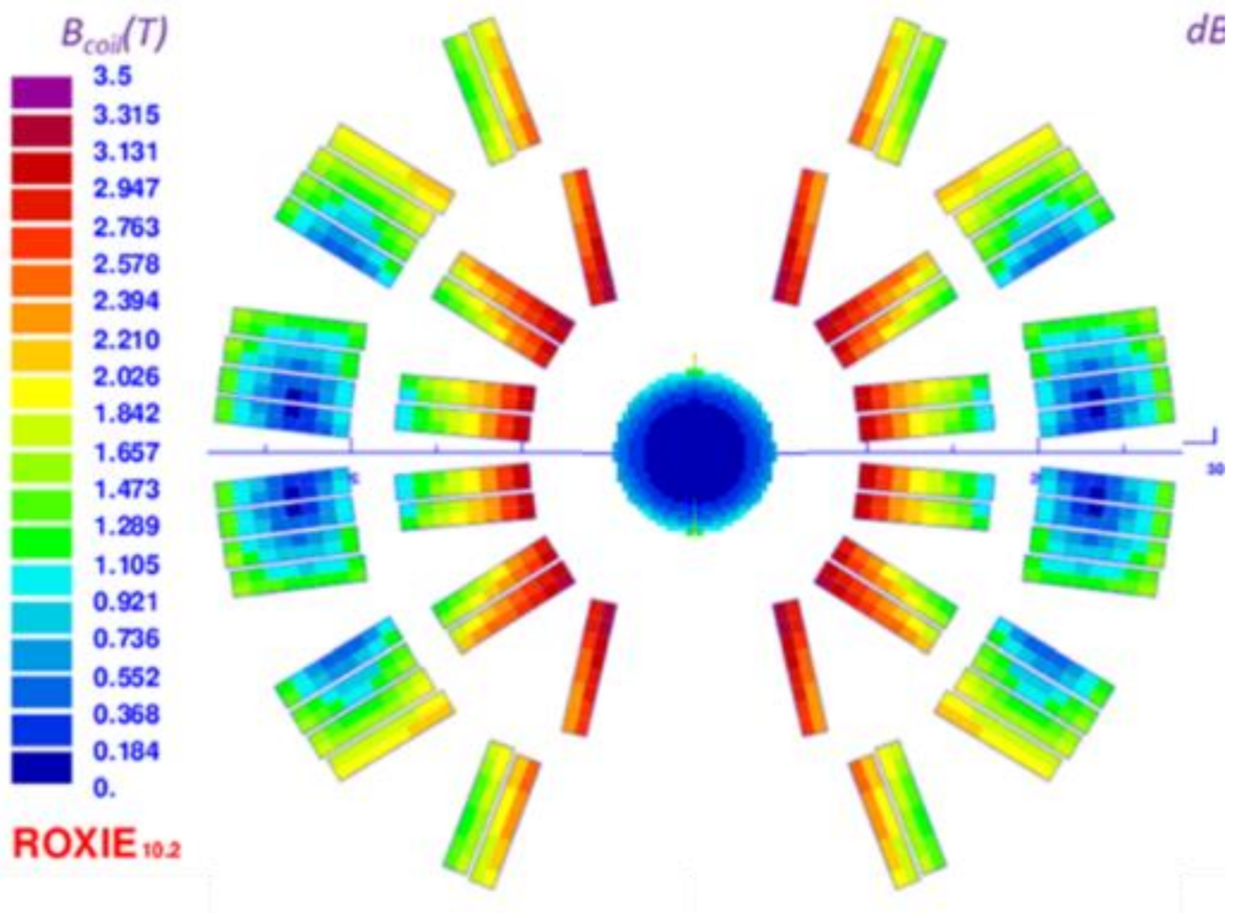
Introduction

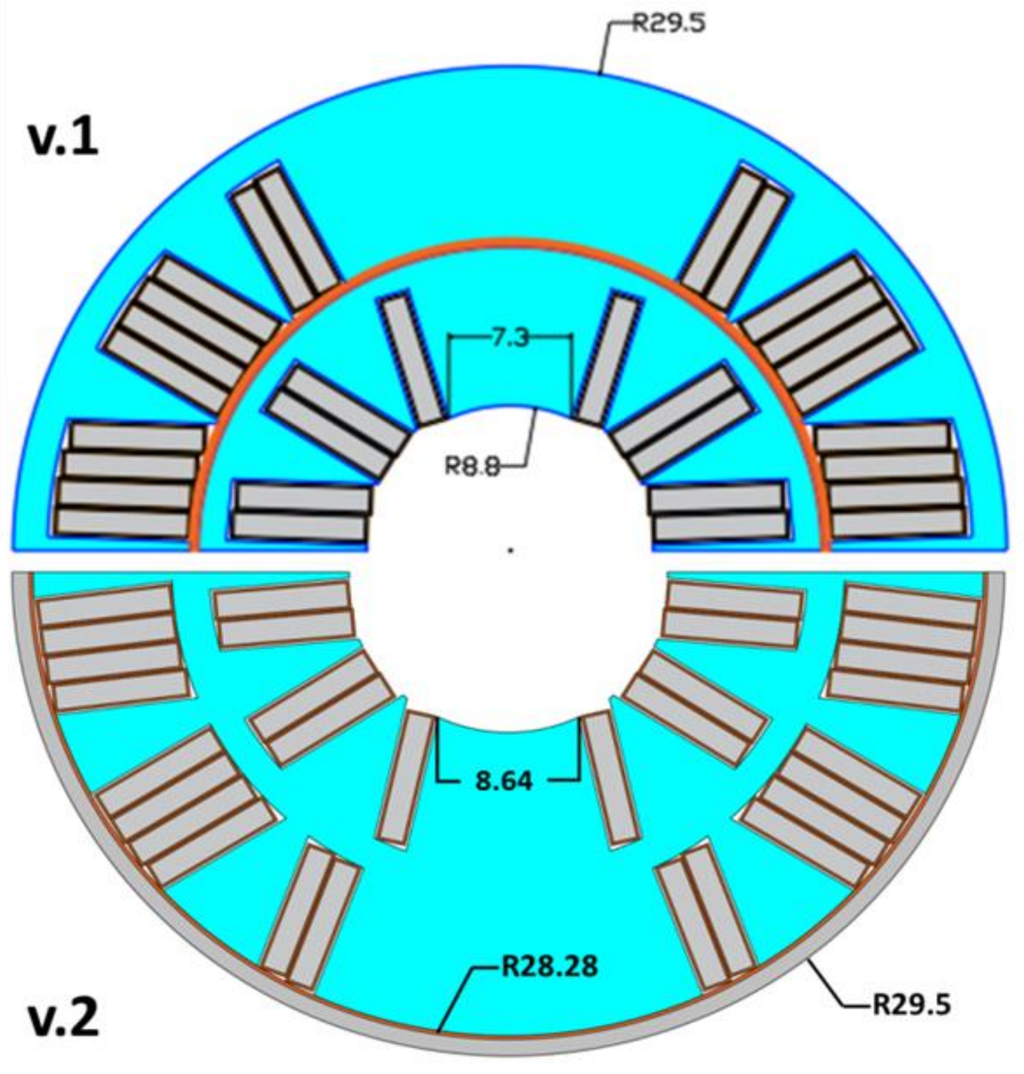
Three designs of Bi2212 insert coil and SMCT coil support structure have been developed and evaluated.

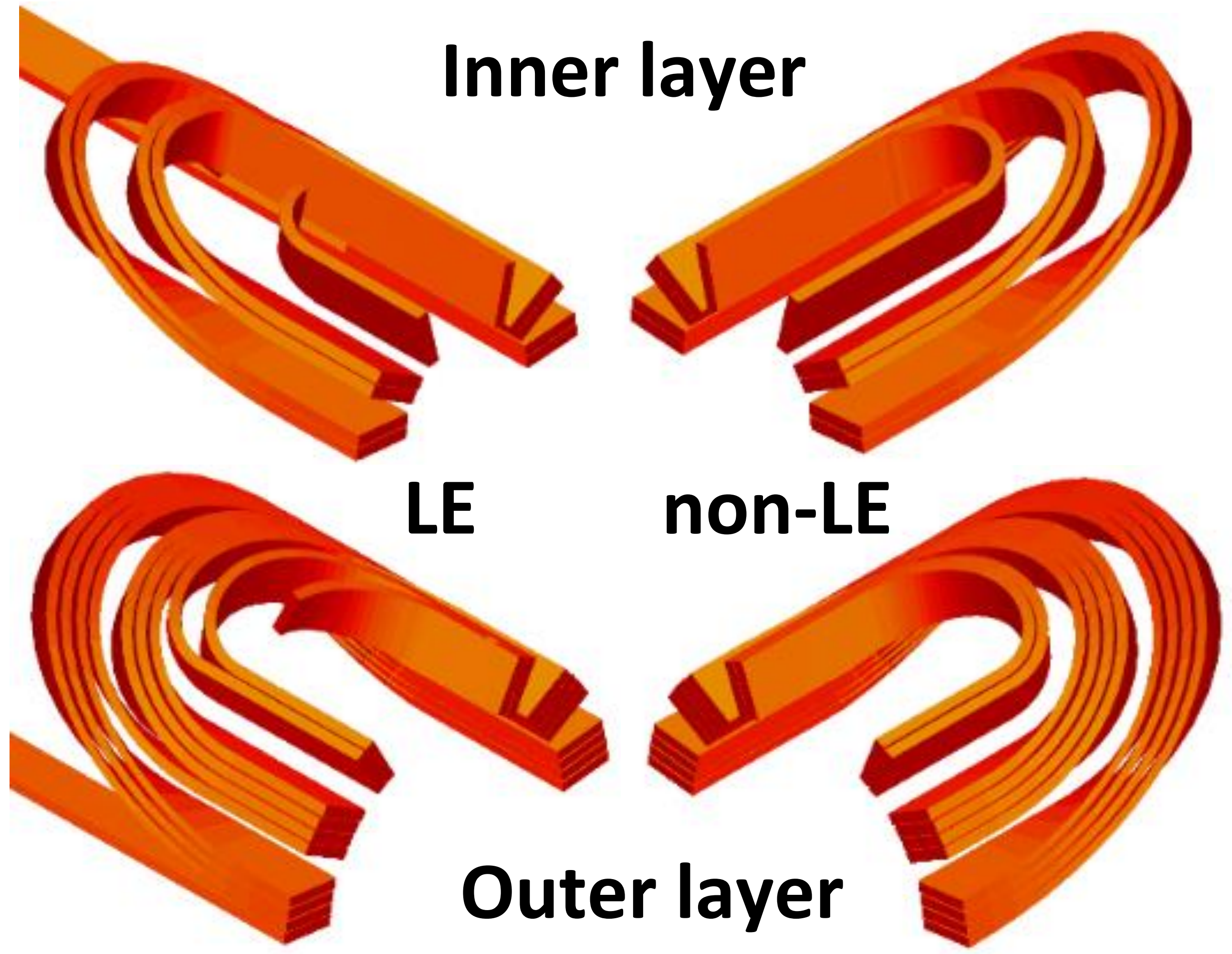
Coil development and optimization included 6 steps:

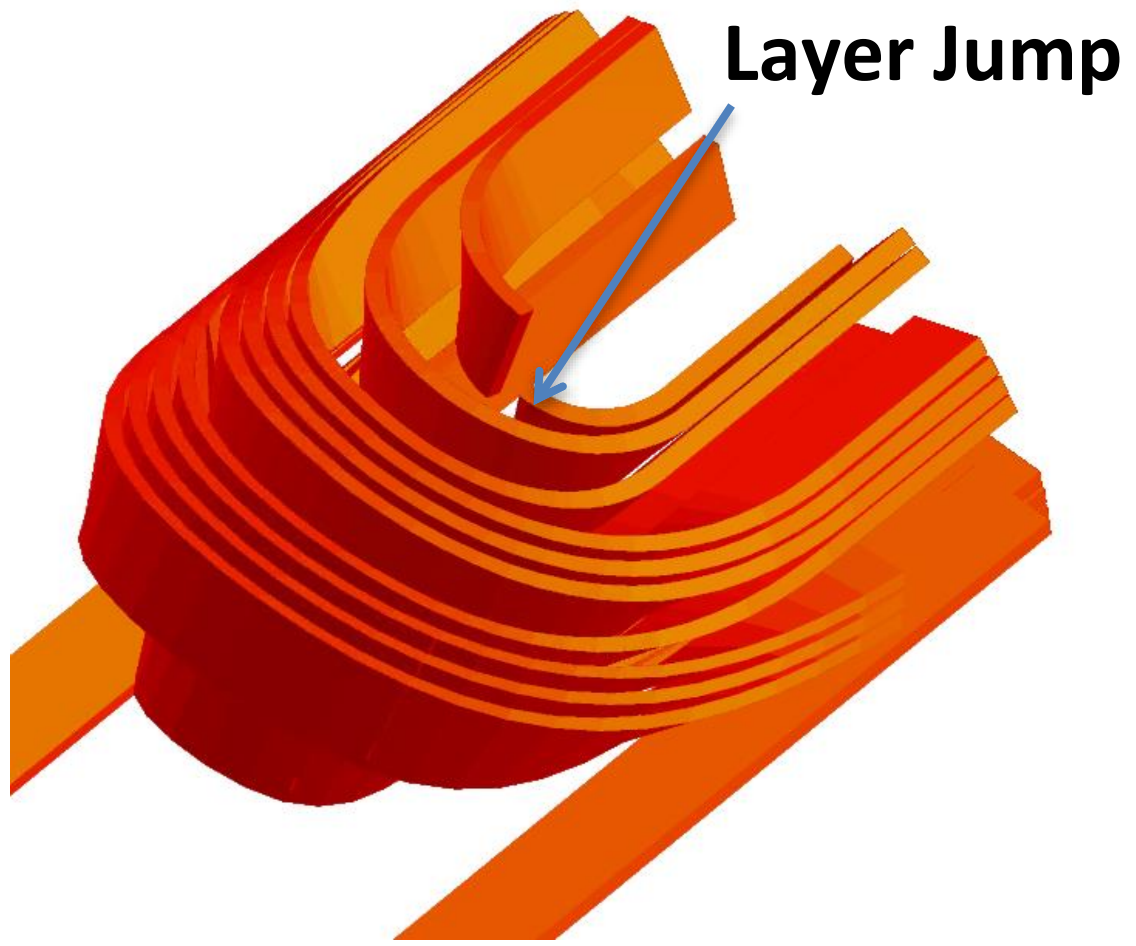
- **Step 1: coil cross-section optimization using 2D ROXIE code.**
- **Step 2: coil end design optimization, produce coil blocks acceptable for Rutherford cable. winding, and minimize transitions between coil end blocks using 3D ROXIE code.**
- **Step 3: part solid model using NX software.**
- **Step 4: plastic part fabrication using 3D printing technology.**
- **Step 5: "dummy" cable testing and selection.**
- **Step 6: practice coil winding.**

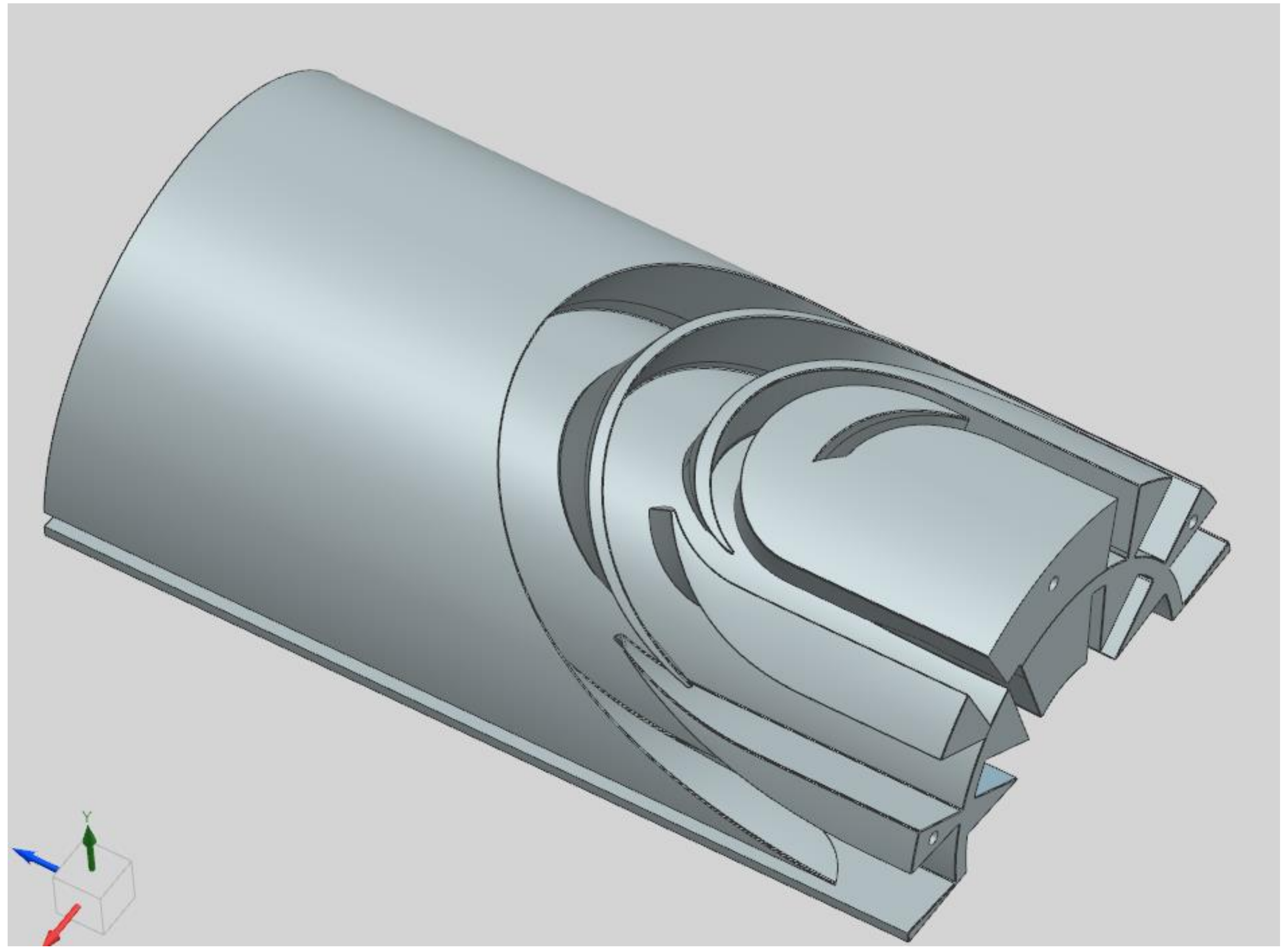
2-layer 6-block coil (Design 1)



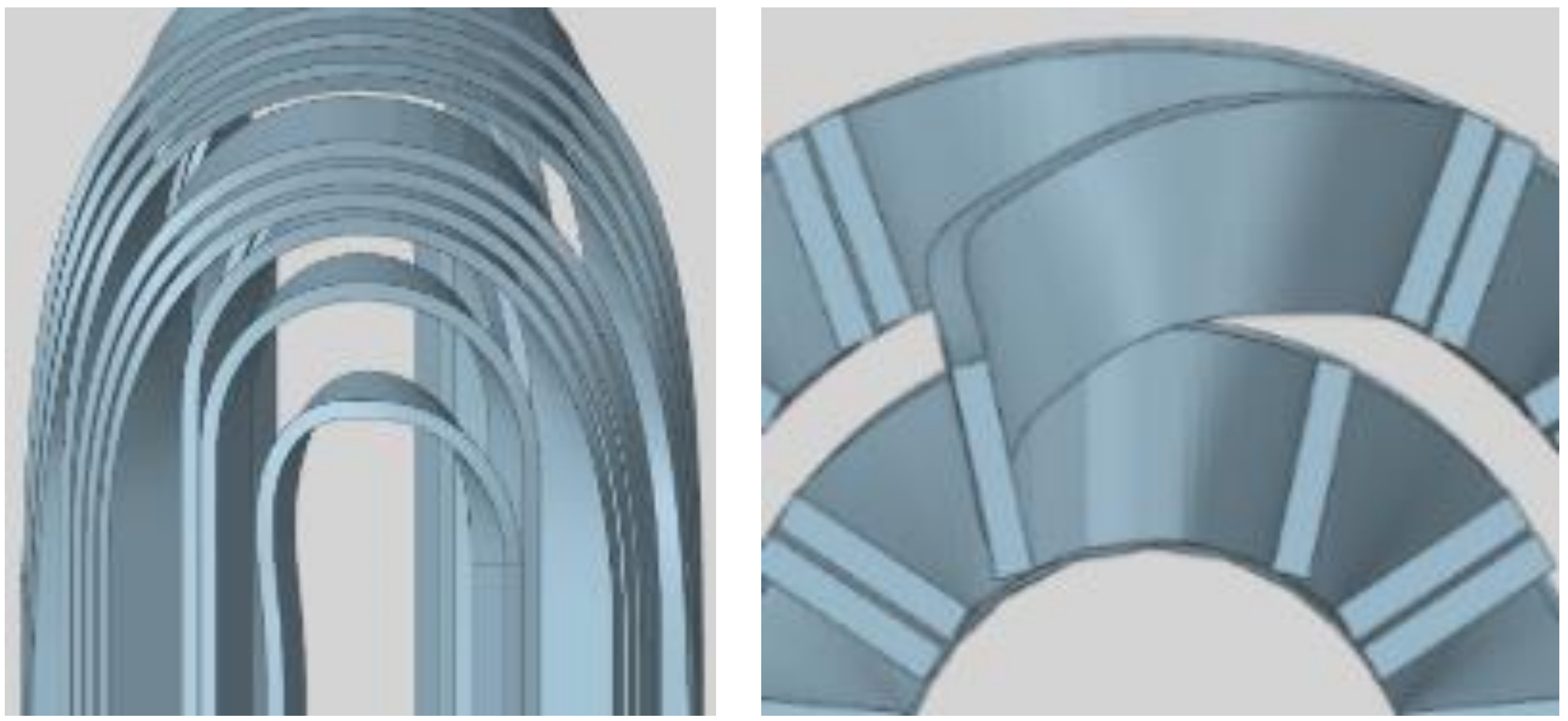








Inner-layer transition



v.1:
- separate structure for each layer
- both coil winding from inside

v.2:
- one structure for both layers provides larger bore
- IL winding from inside
- OL winding from outside

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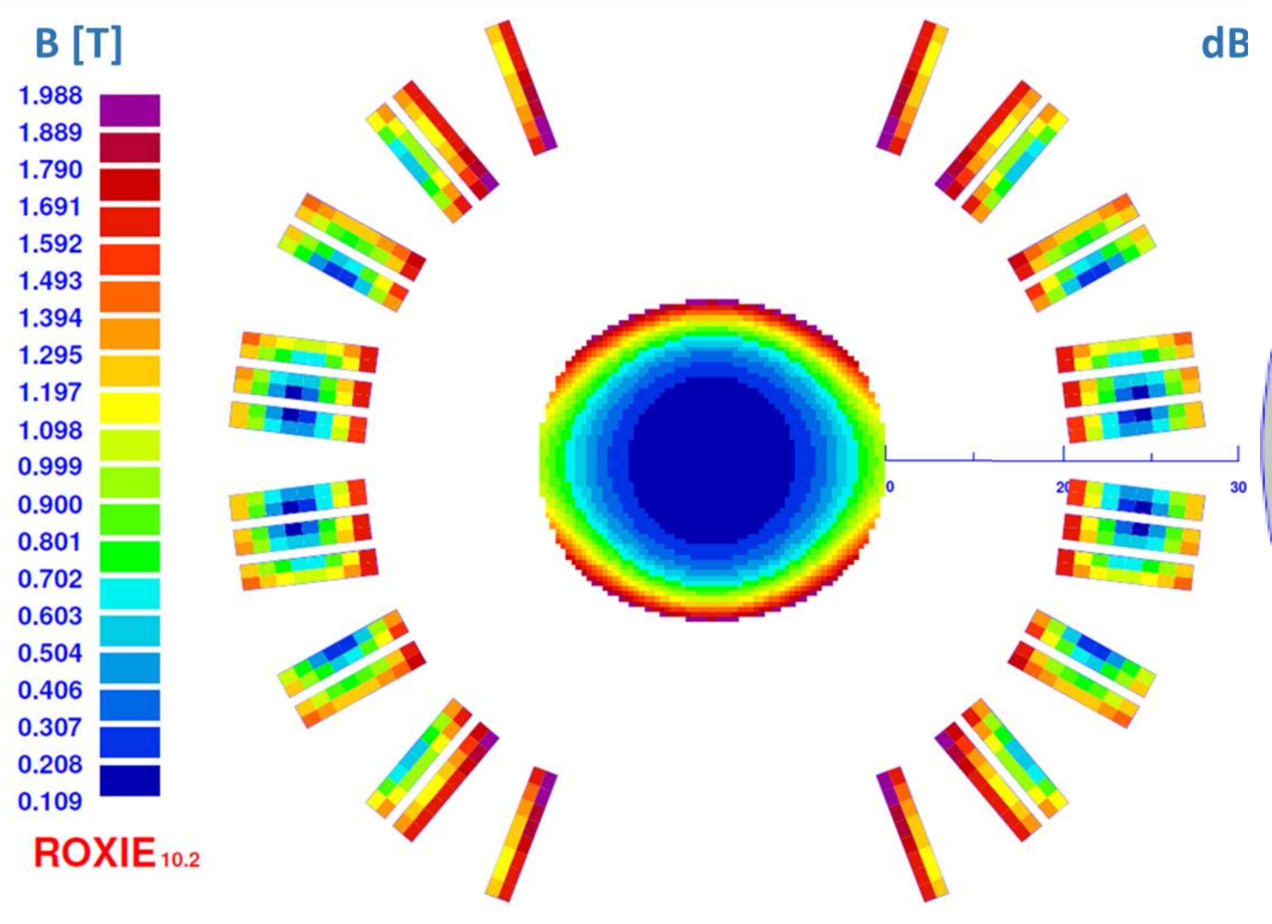
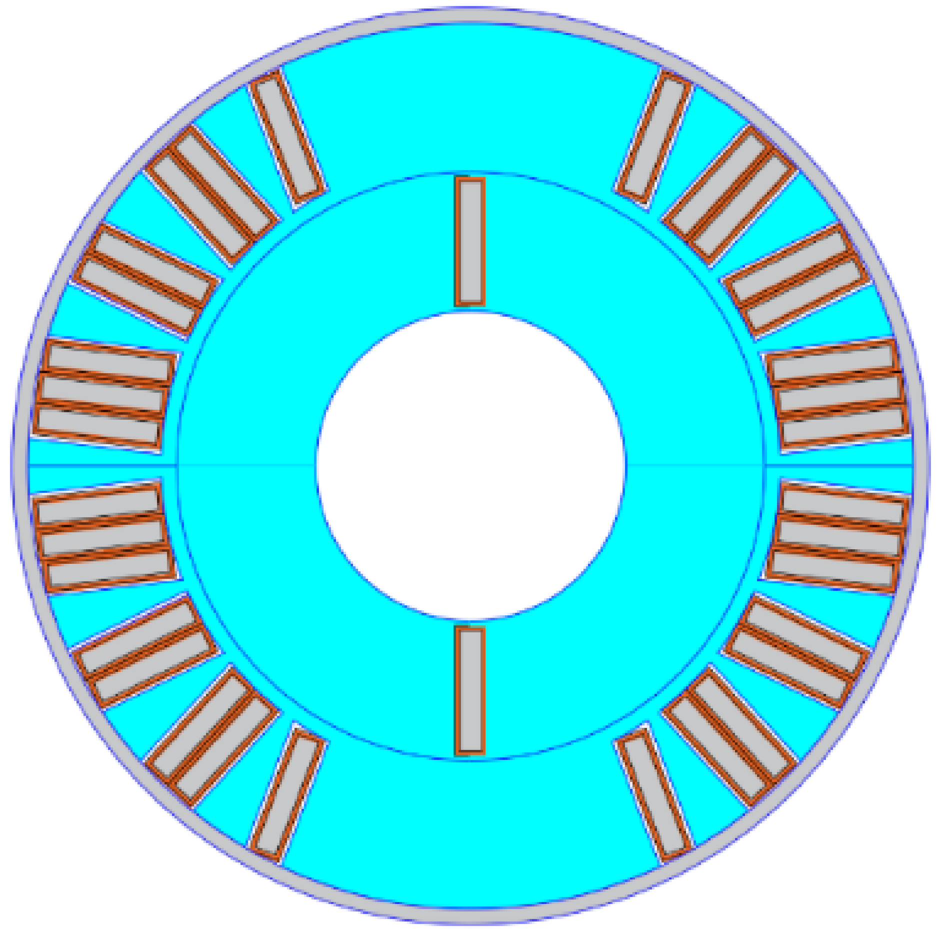
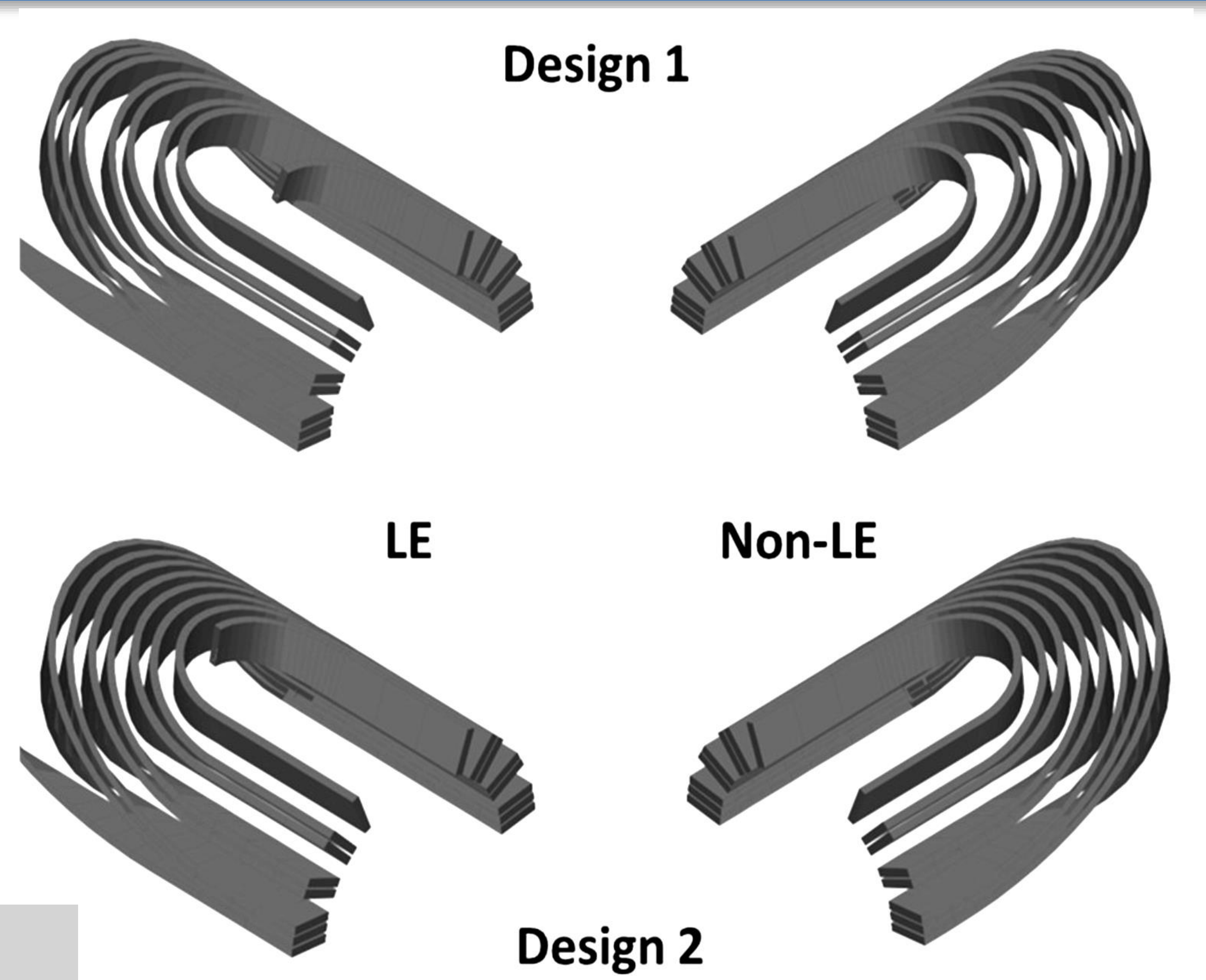
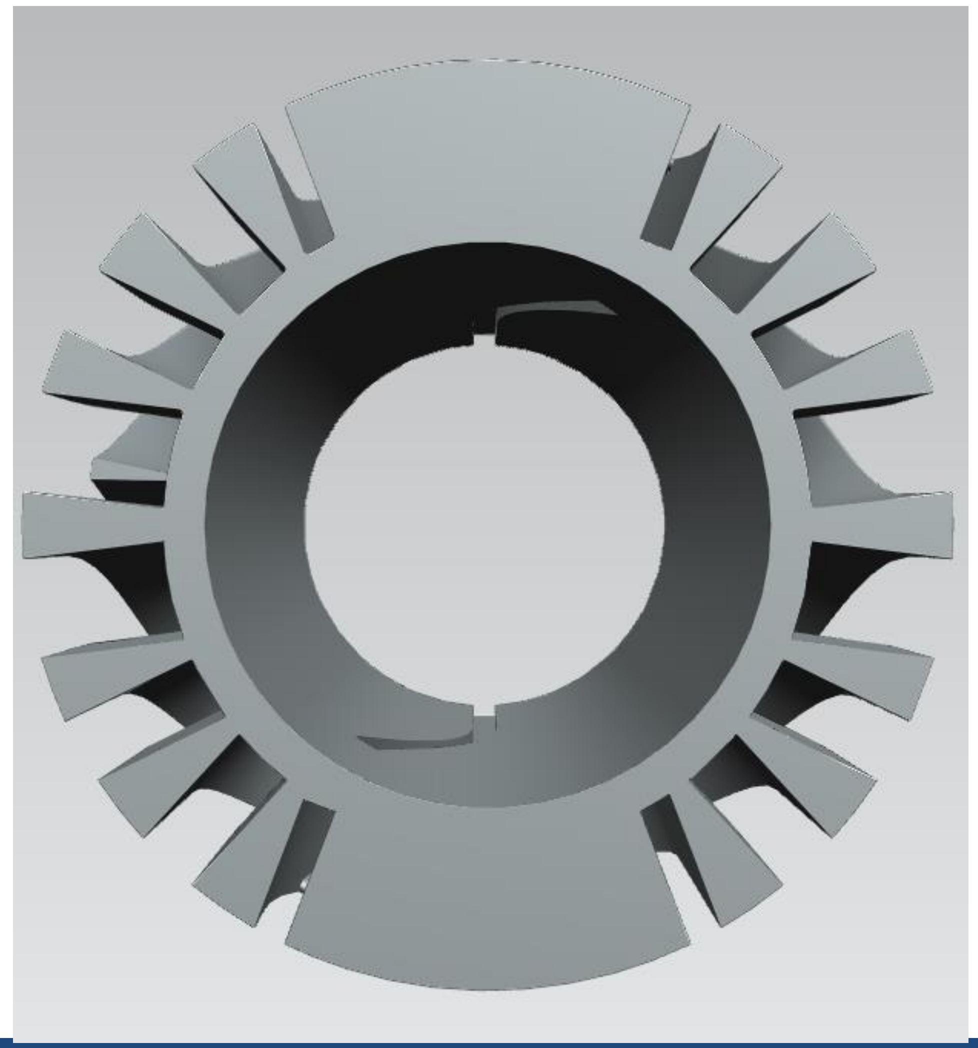
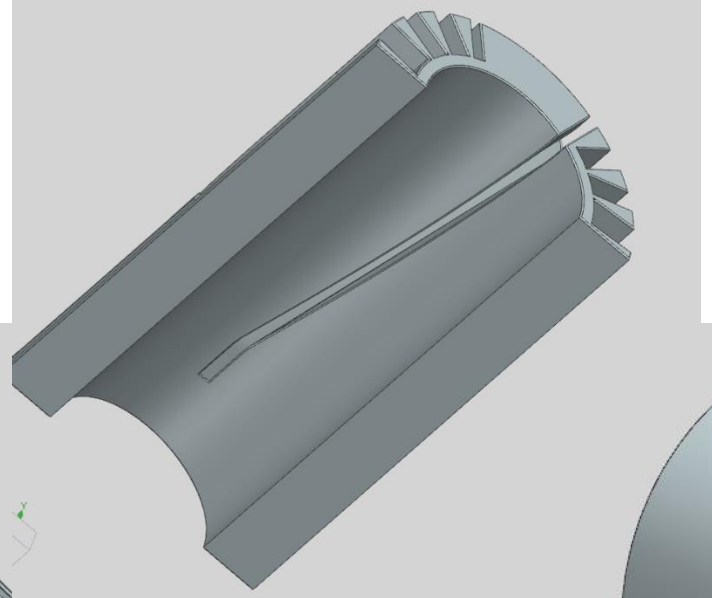
Single-layer 4-block coil (Design 2)

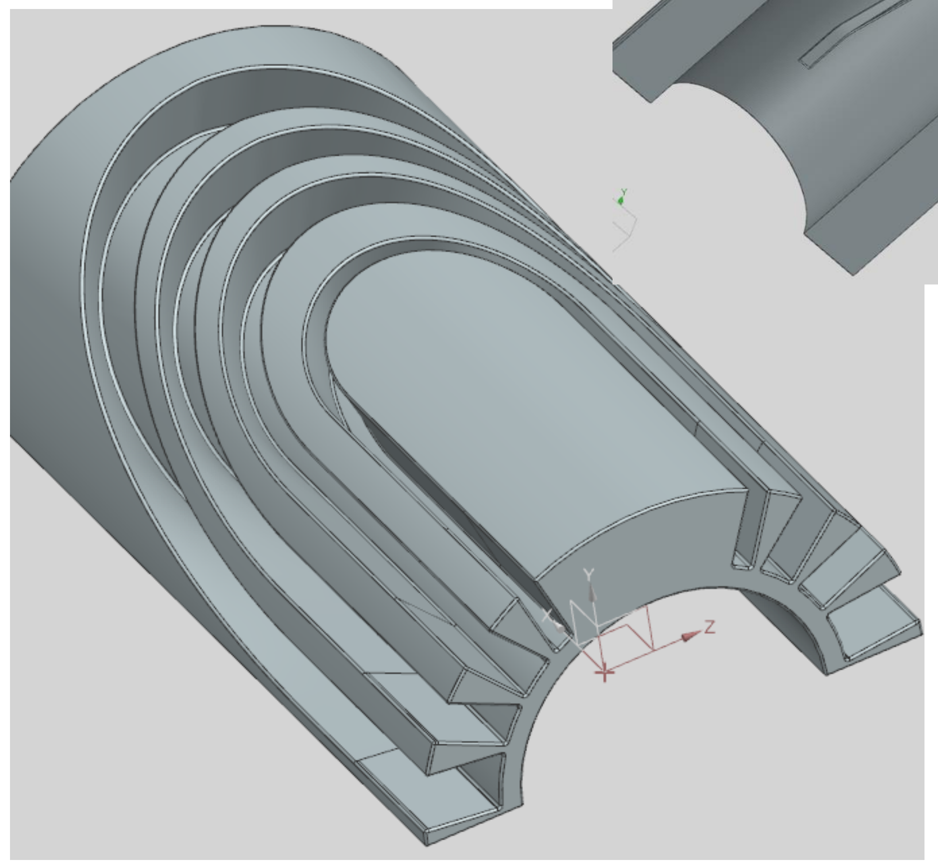


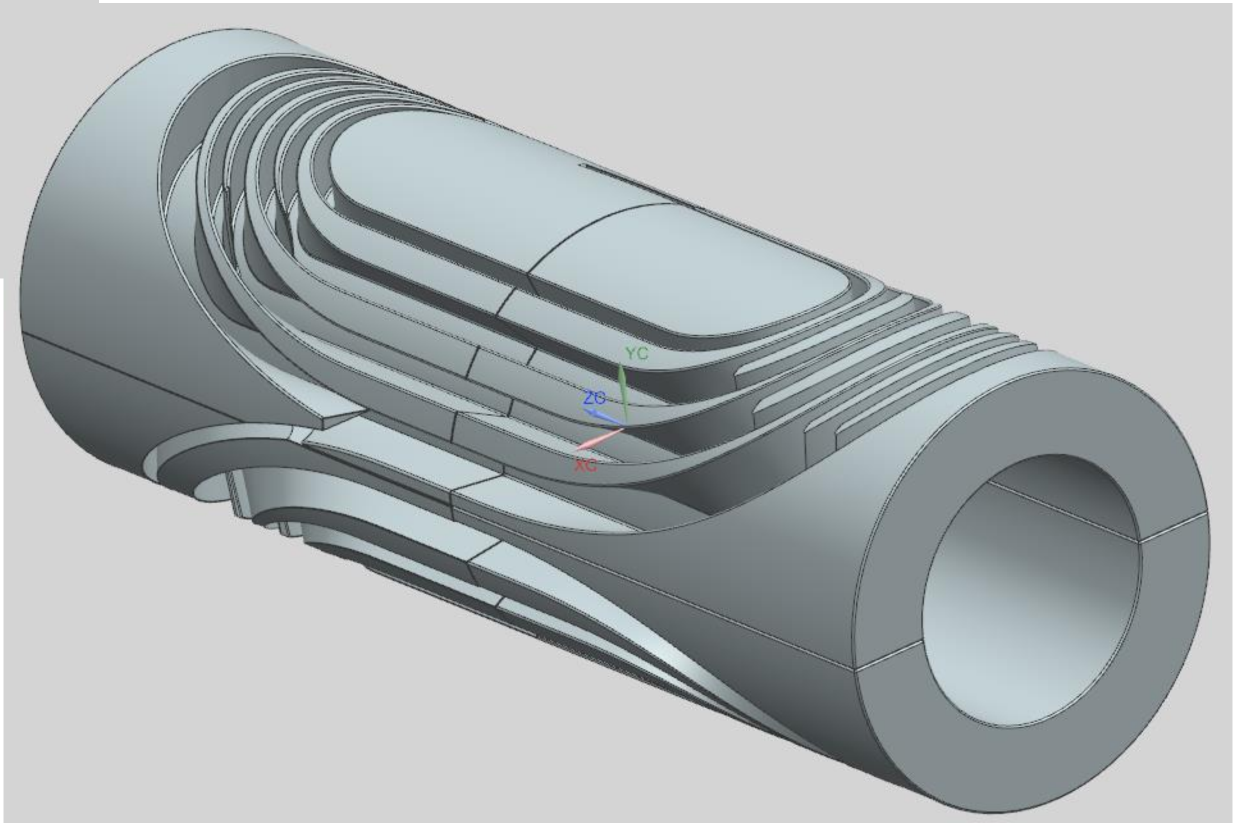












Design 2-1:

- end turns are grouped in blocks as in the coil straight section
- short inter-block transitions

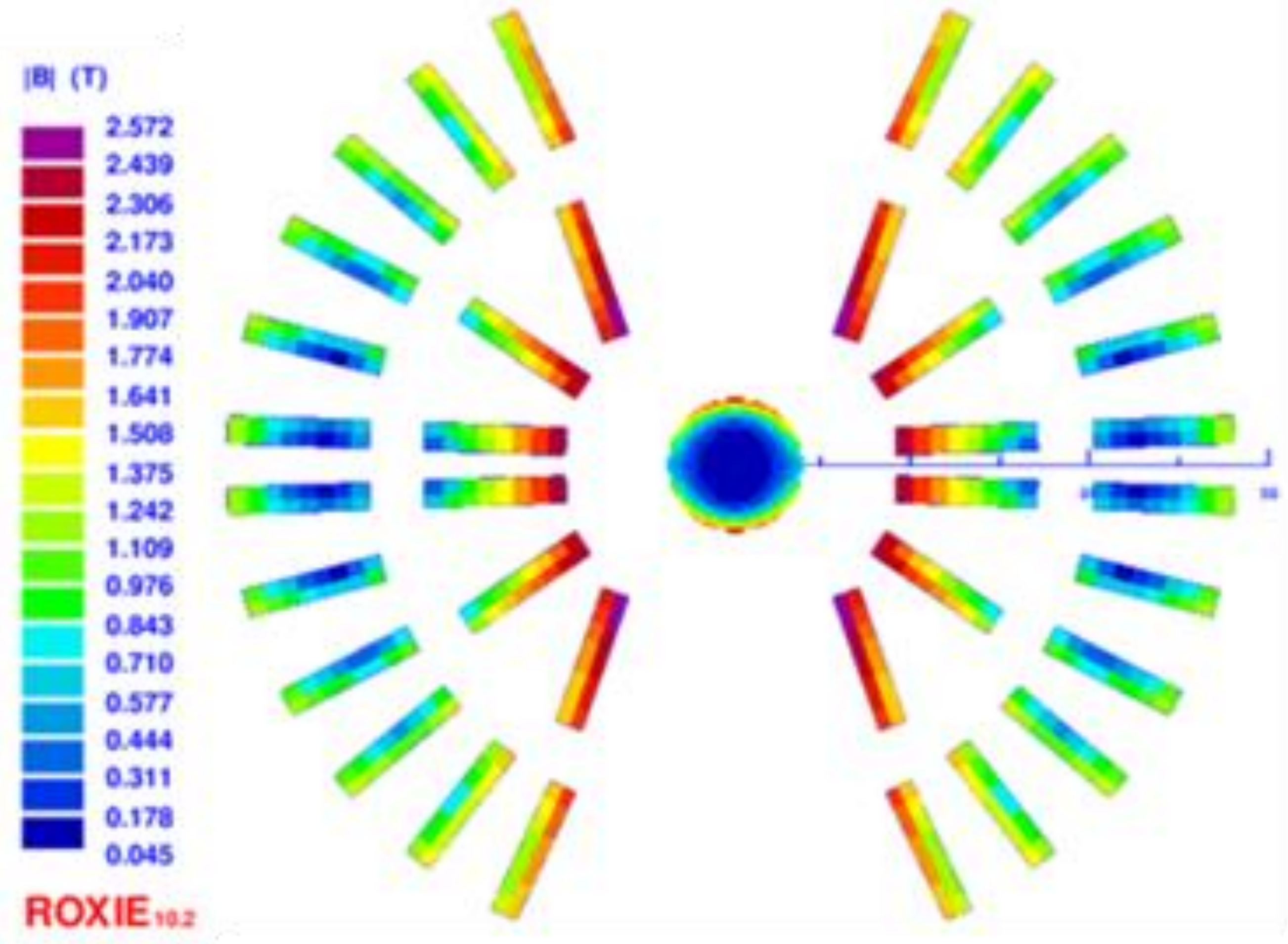
Design 2-2:

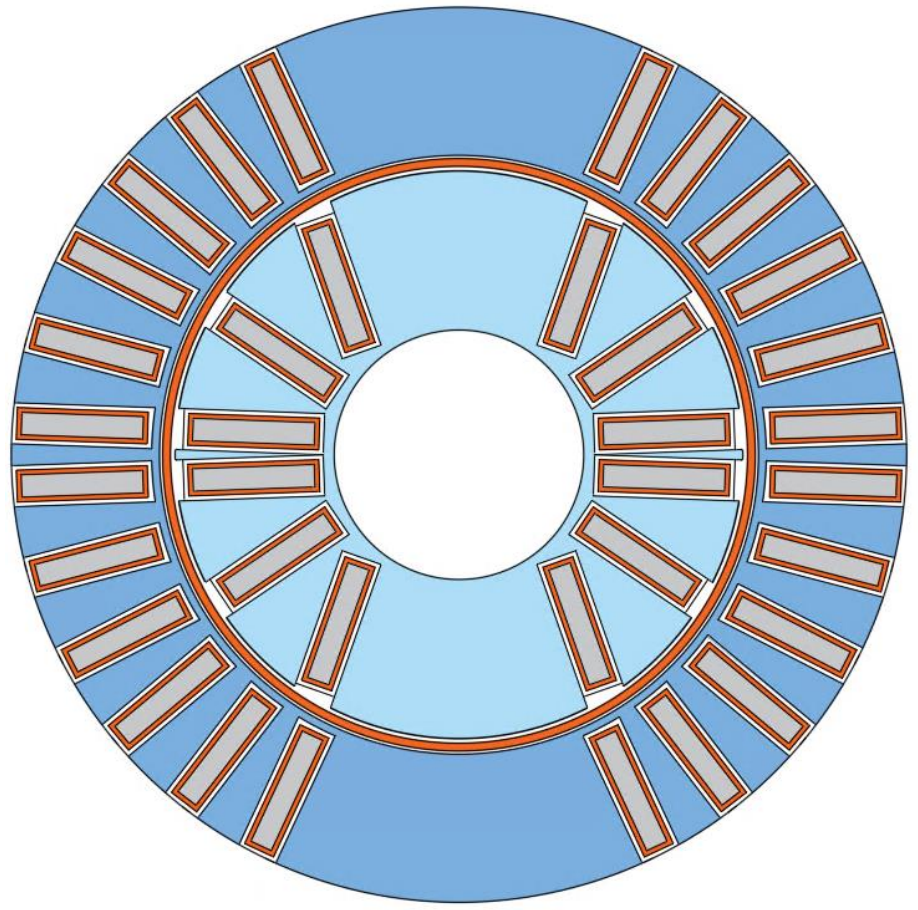
- each end turn in its separate grove

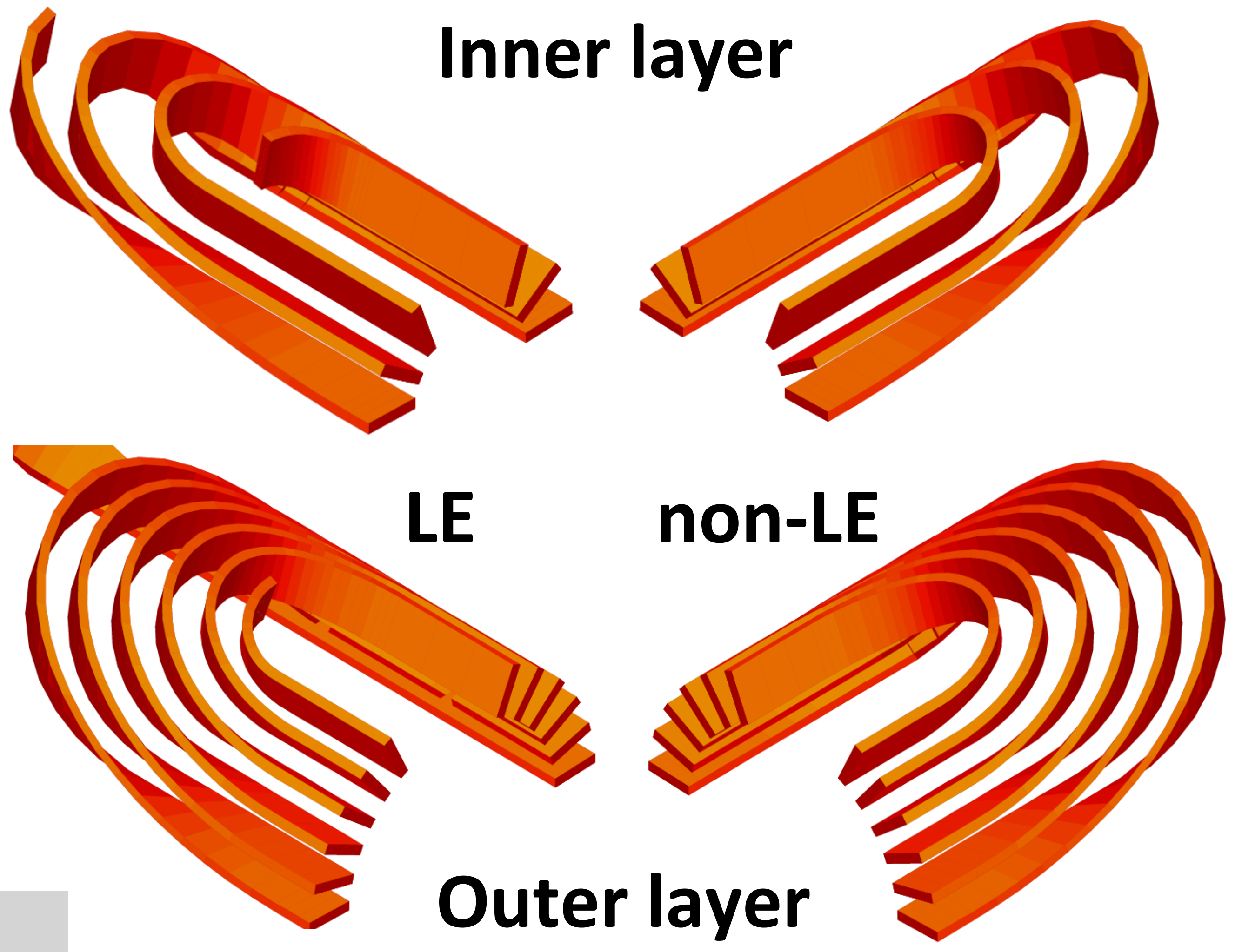
General features:

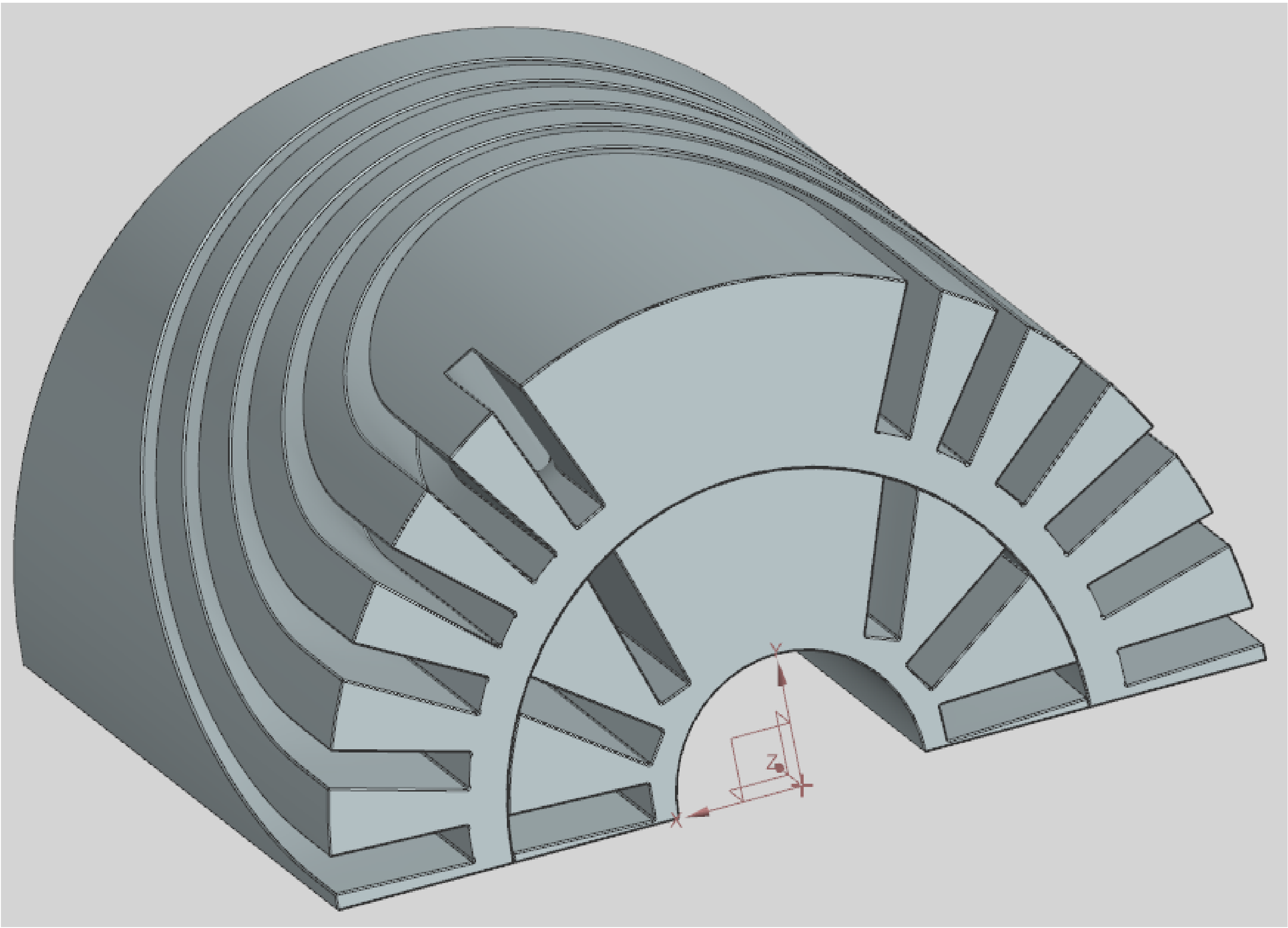
- Coil leads go through aperture reducing the bore diameter
- Coil winding from outside
- Two separate half-coils or one single coil w/o splice

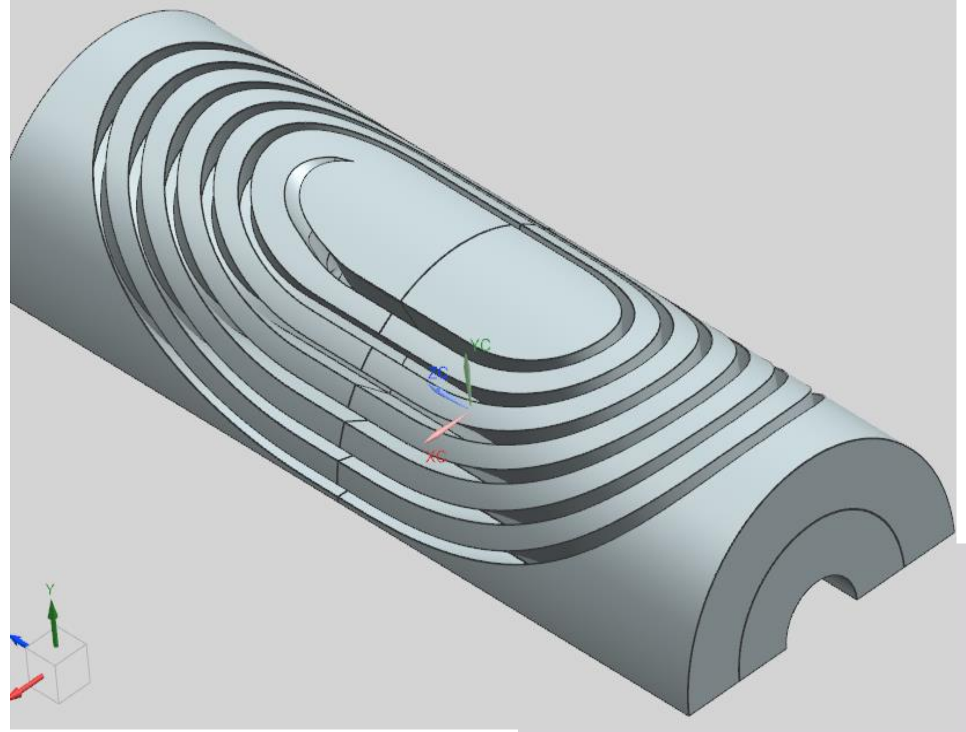
2-layer 9-block coil (Design 3)

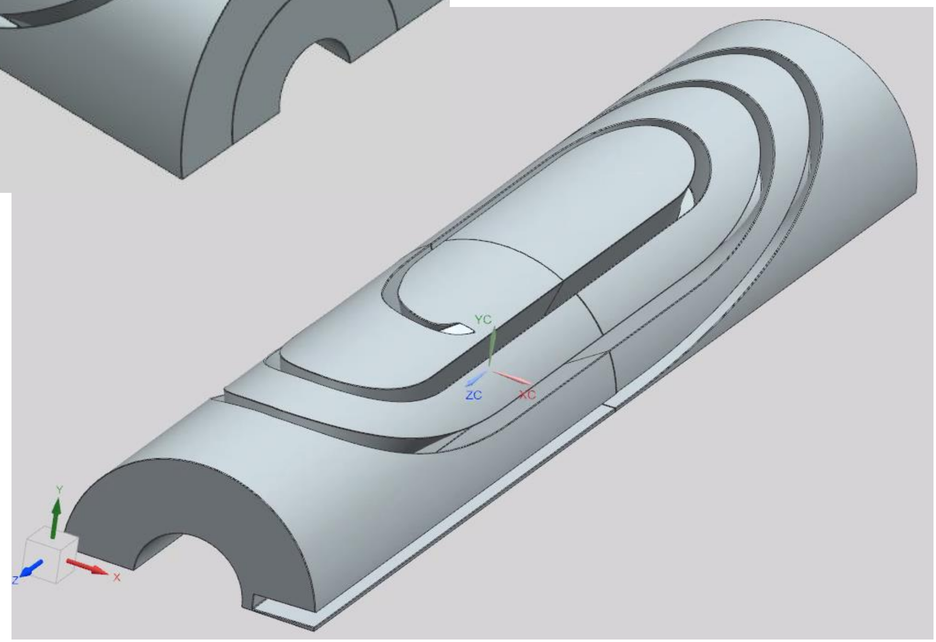


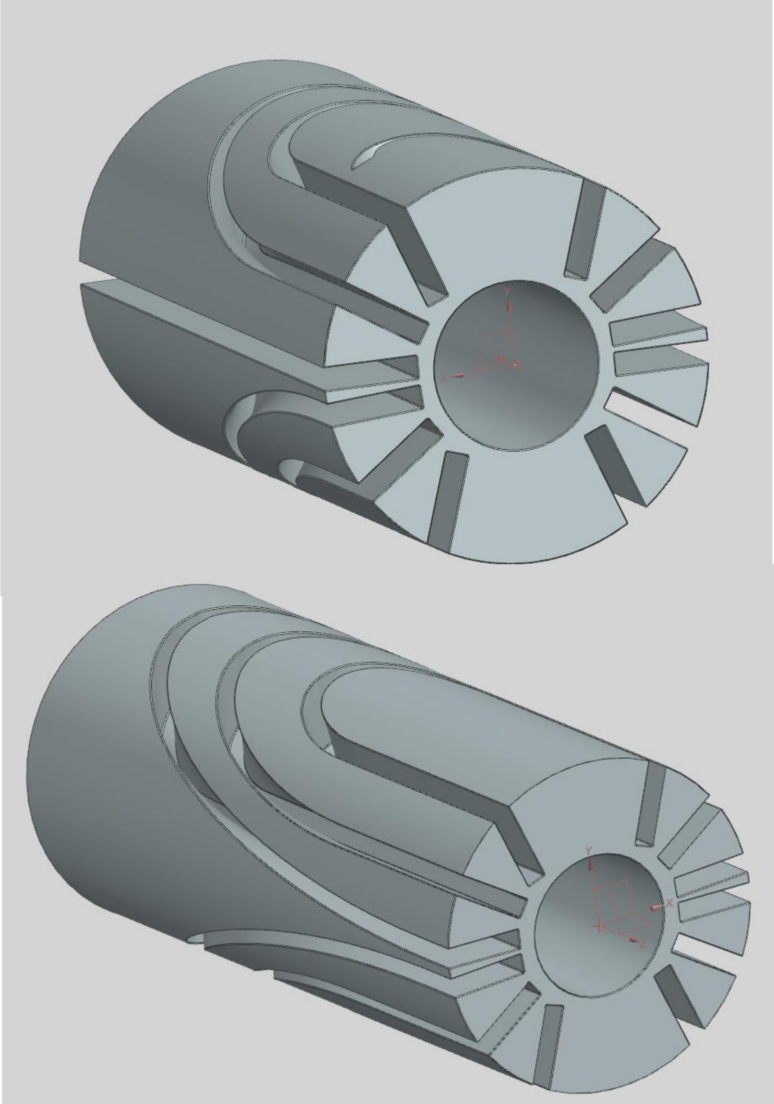












- Separate structure for each layer
- Winding of both layers from outside
- Two coil configurations:

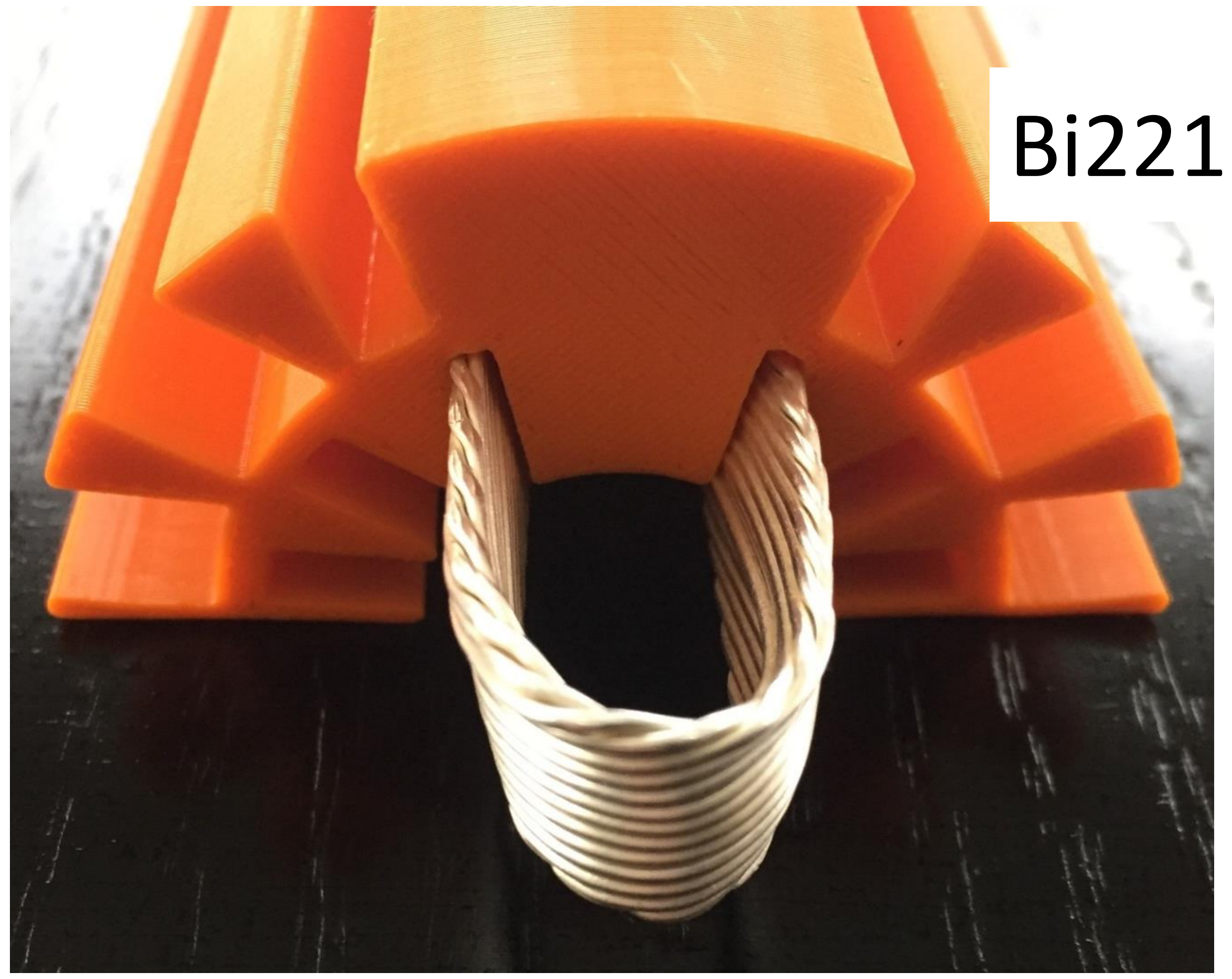
a) separate half-coils

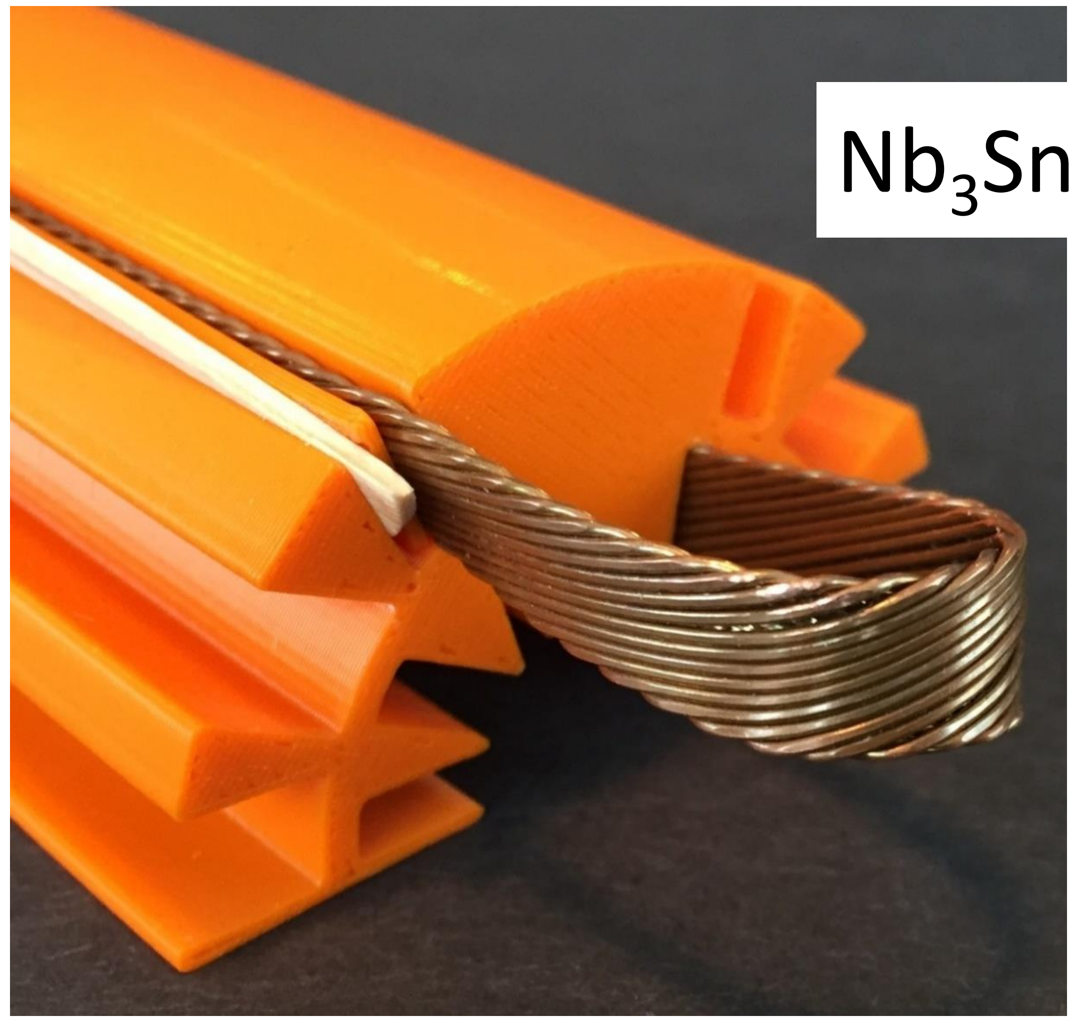
b) one single IL coil w/o splice with separate OL half-coils

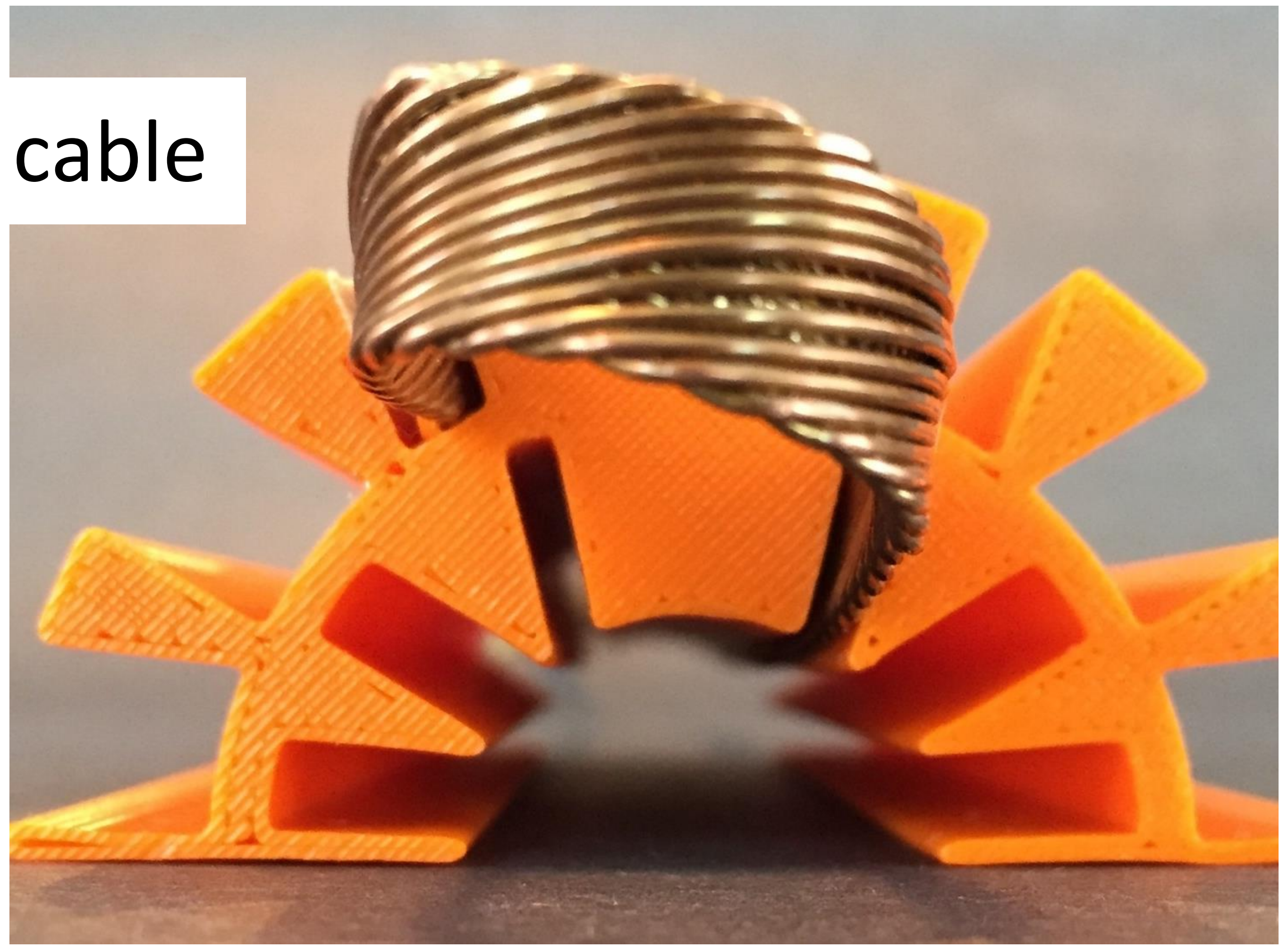
Effect of cable mechanical properties

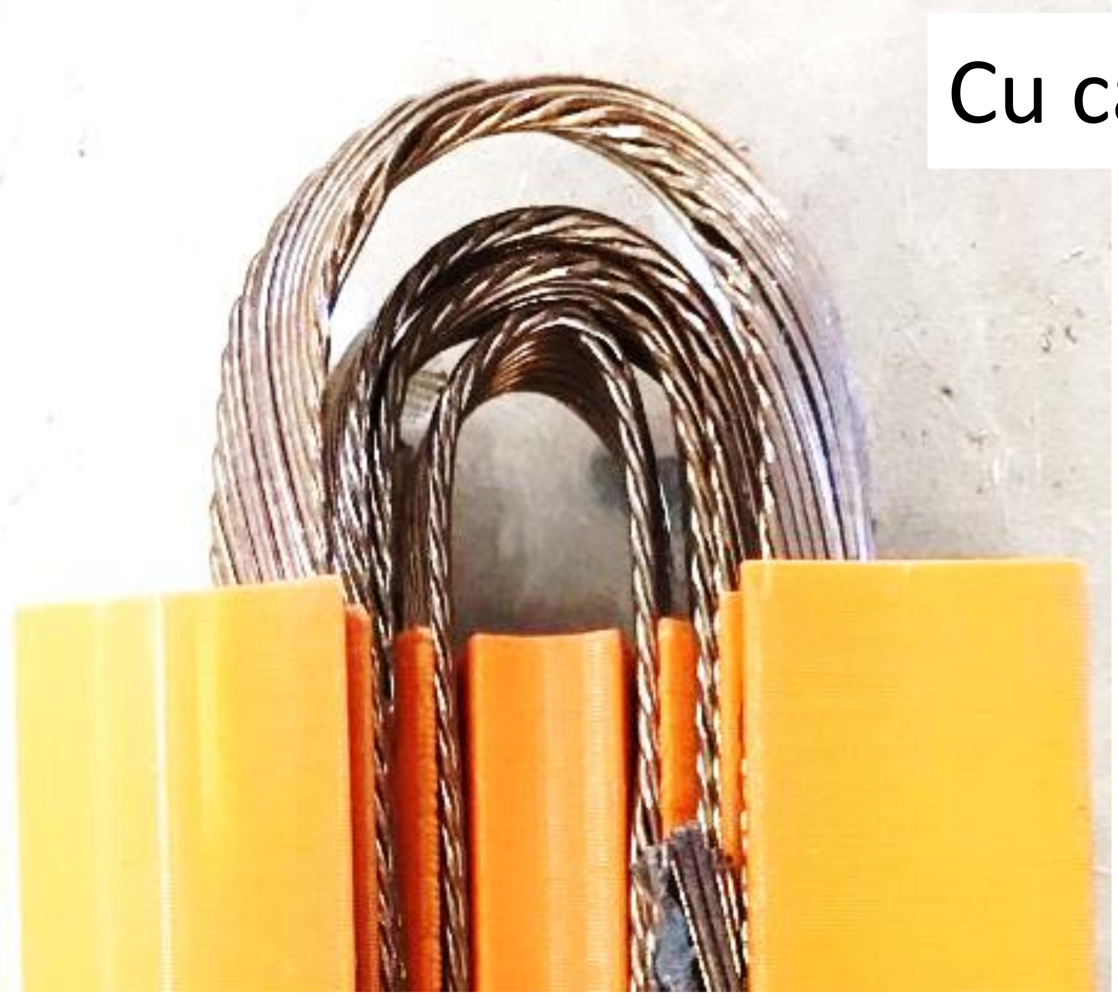
Practice winding of key turns using Bi2212, Nb_3Sn, Cu and Nb-Ti cables with the same width and slightly smaller thickness to check

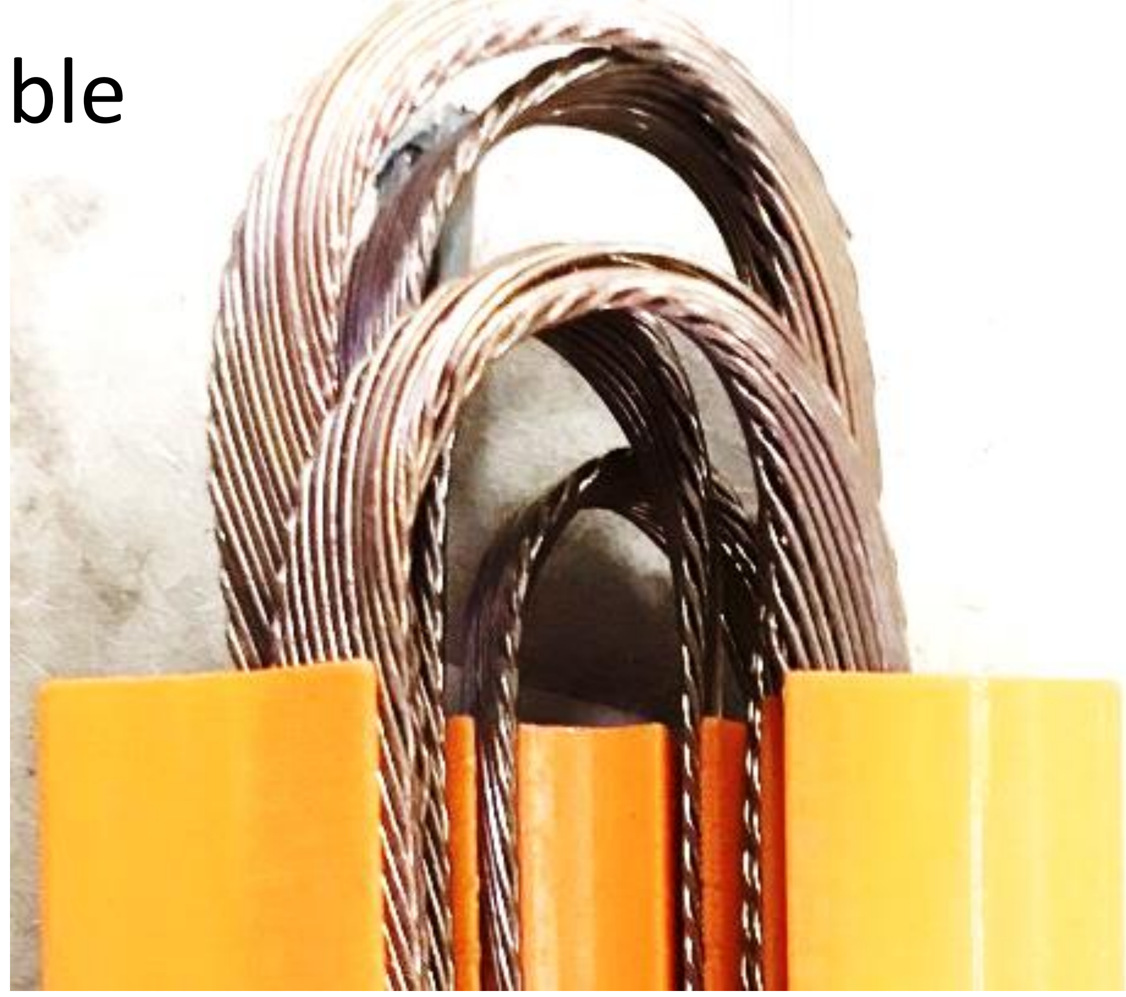
- cable bending around poles
- layer jump



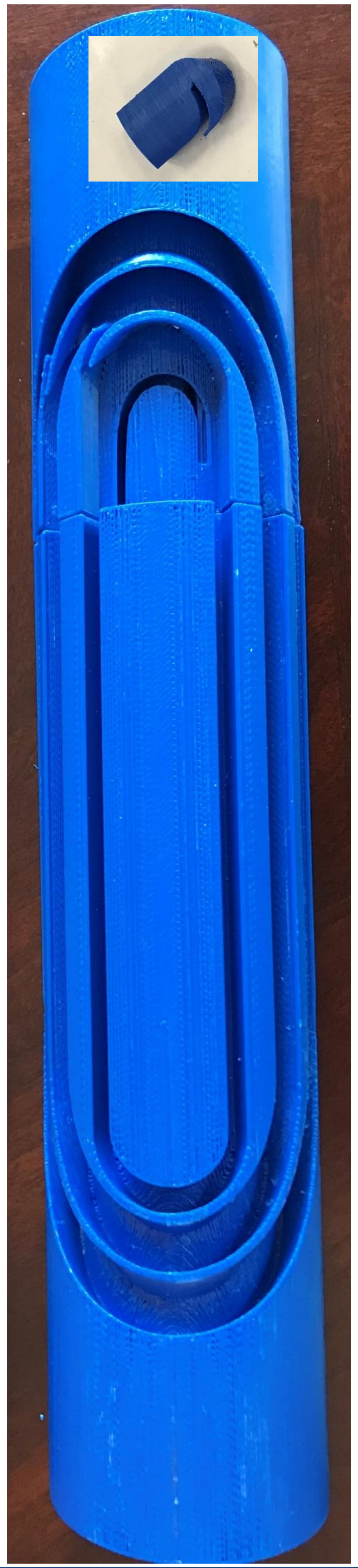


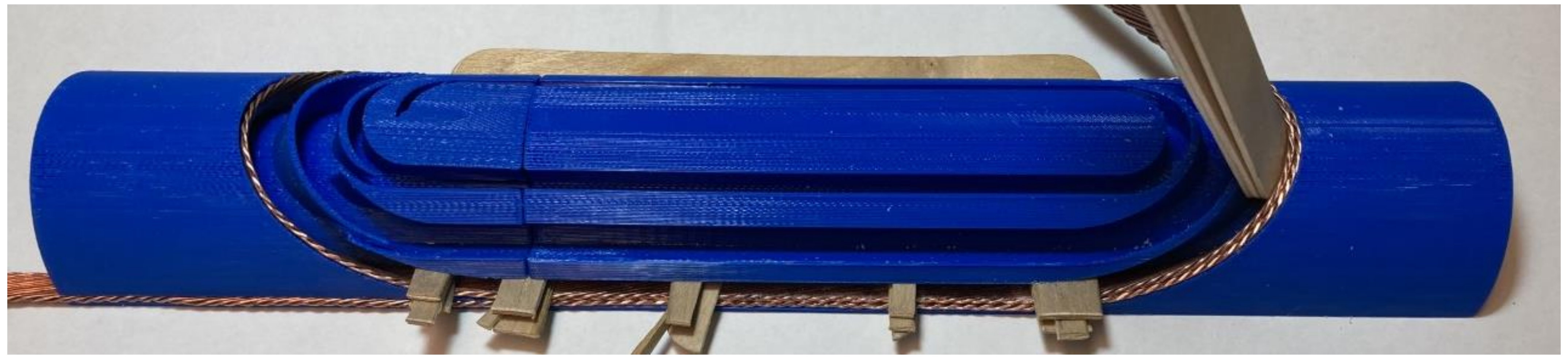


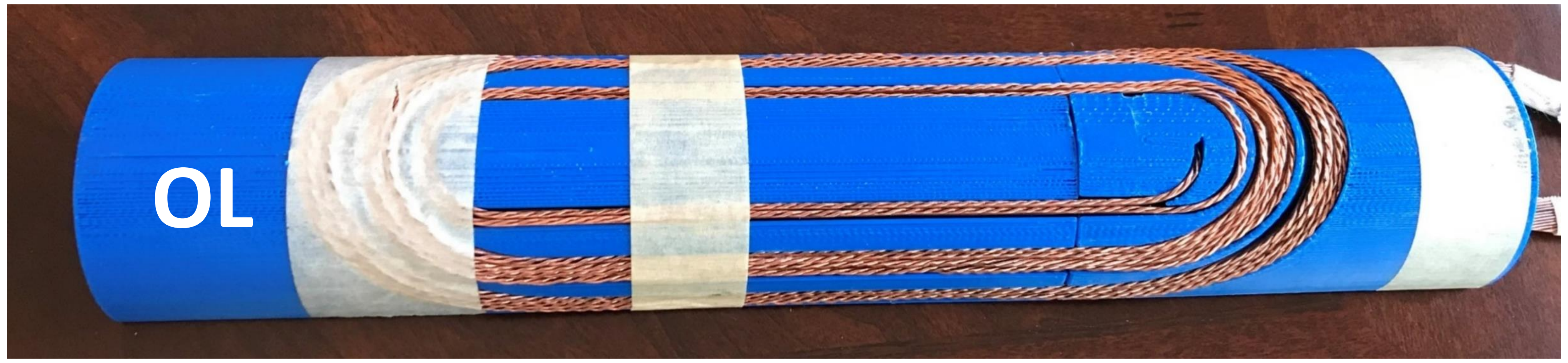


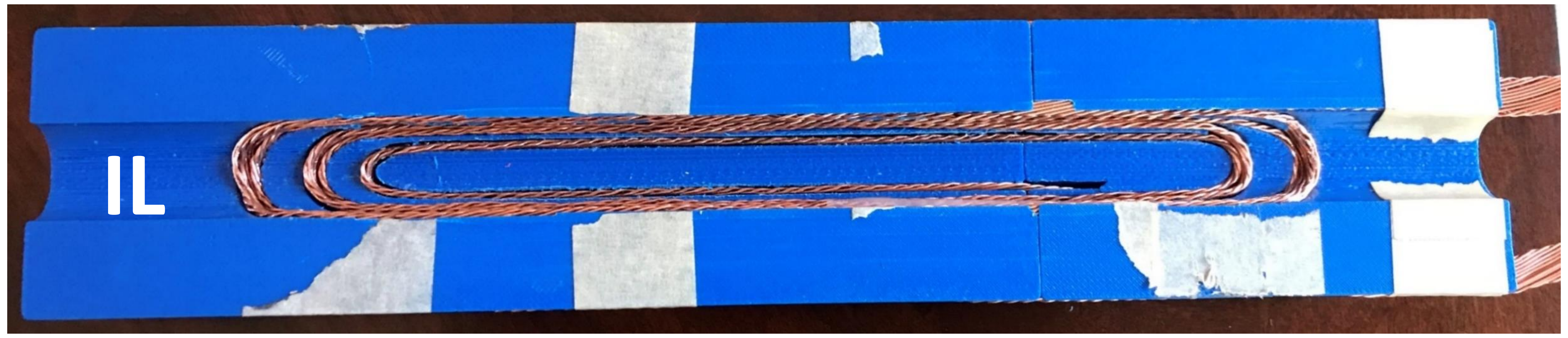


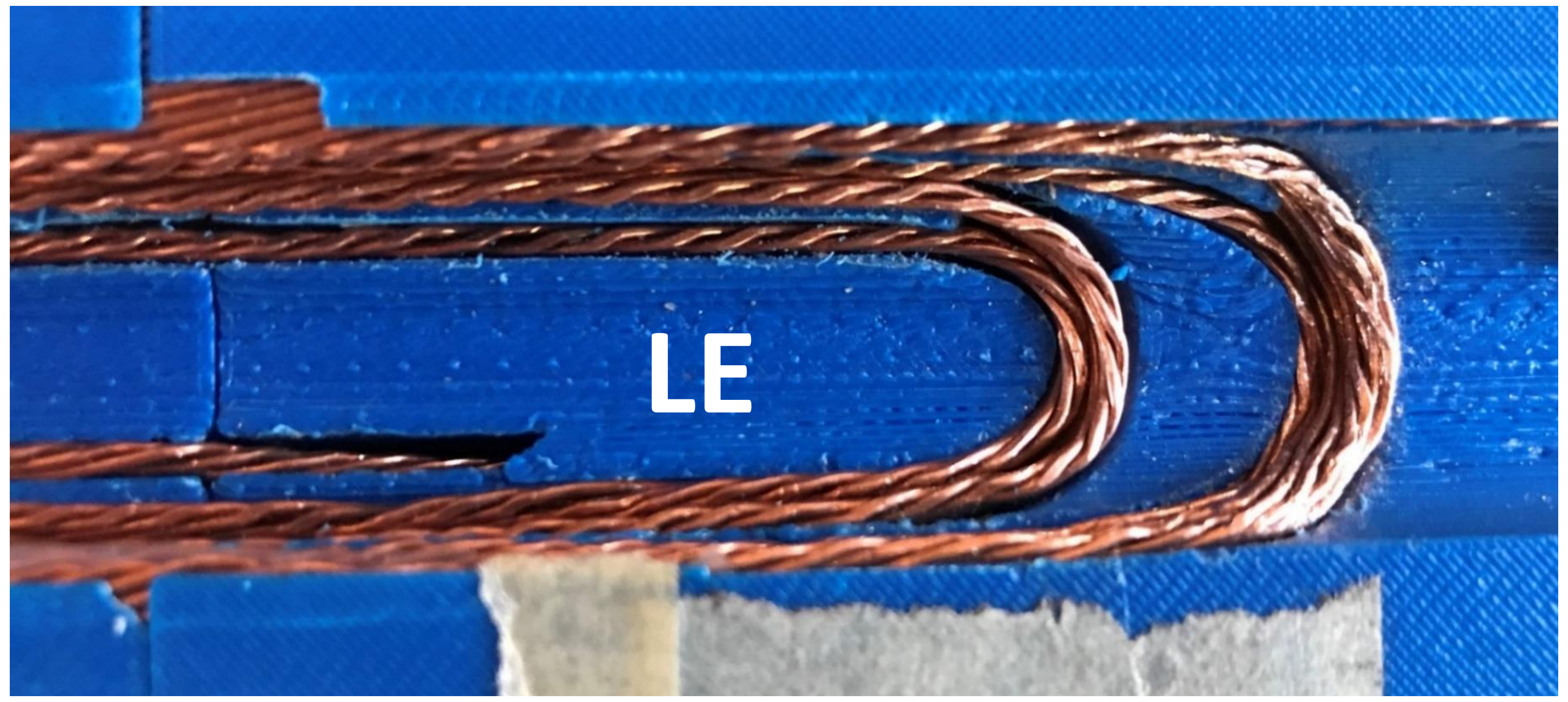
Design 1 practice coils

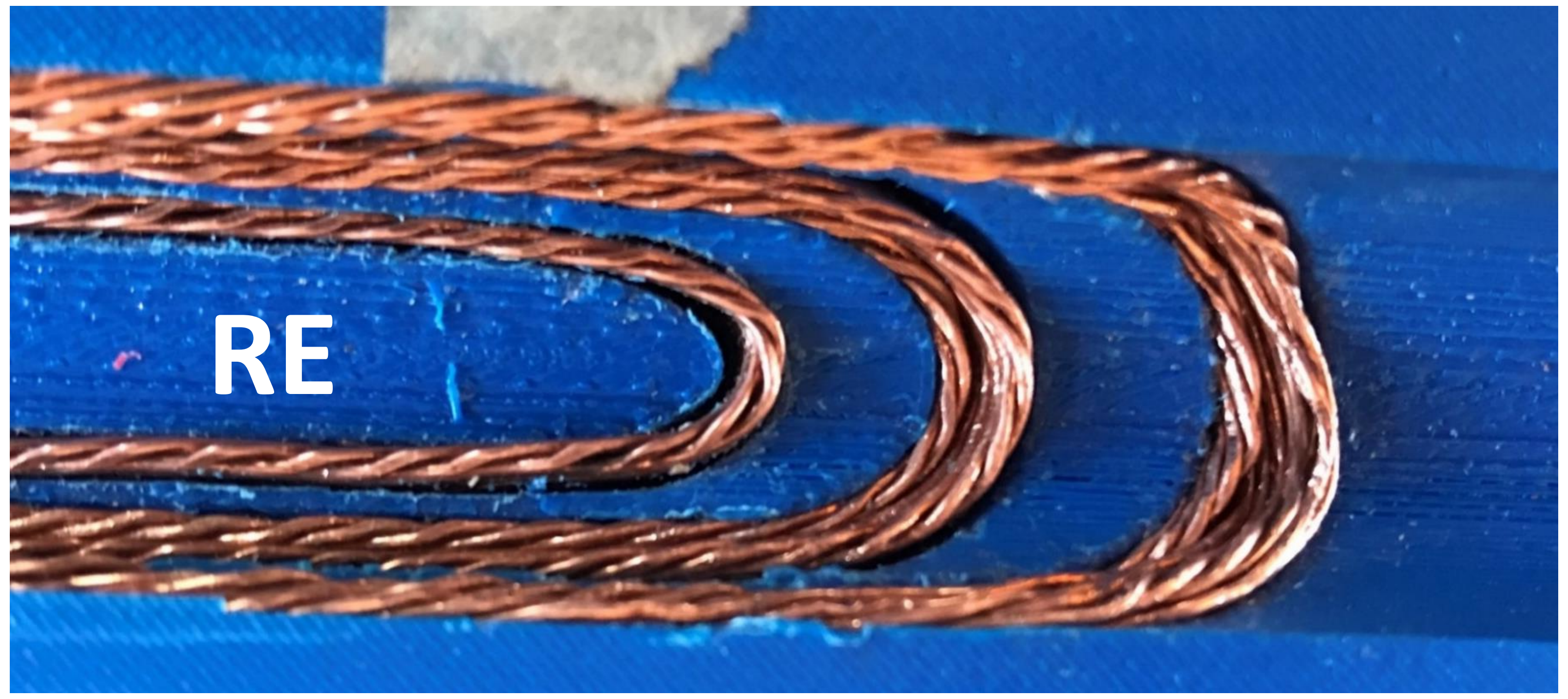












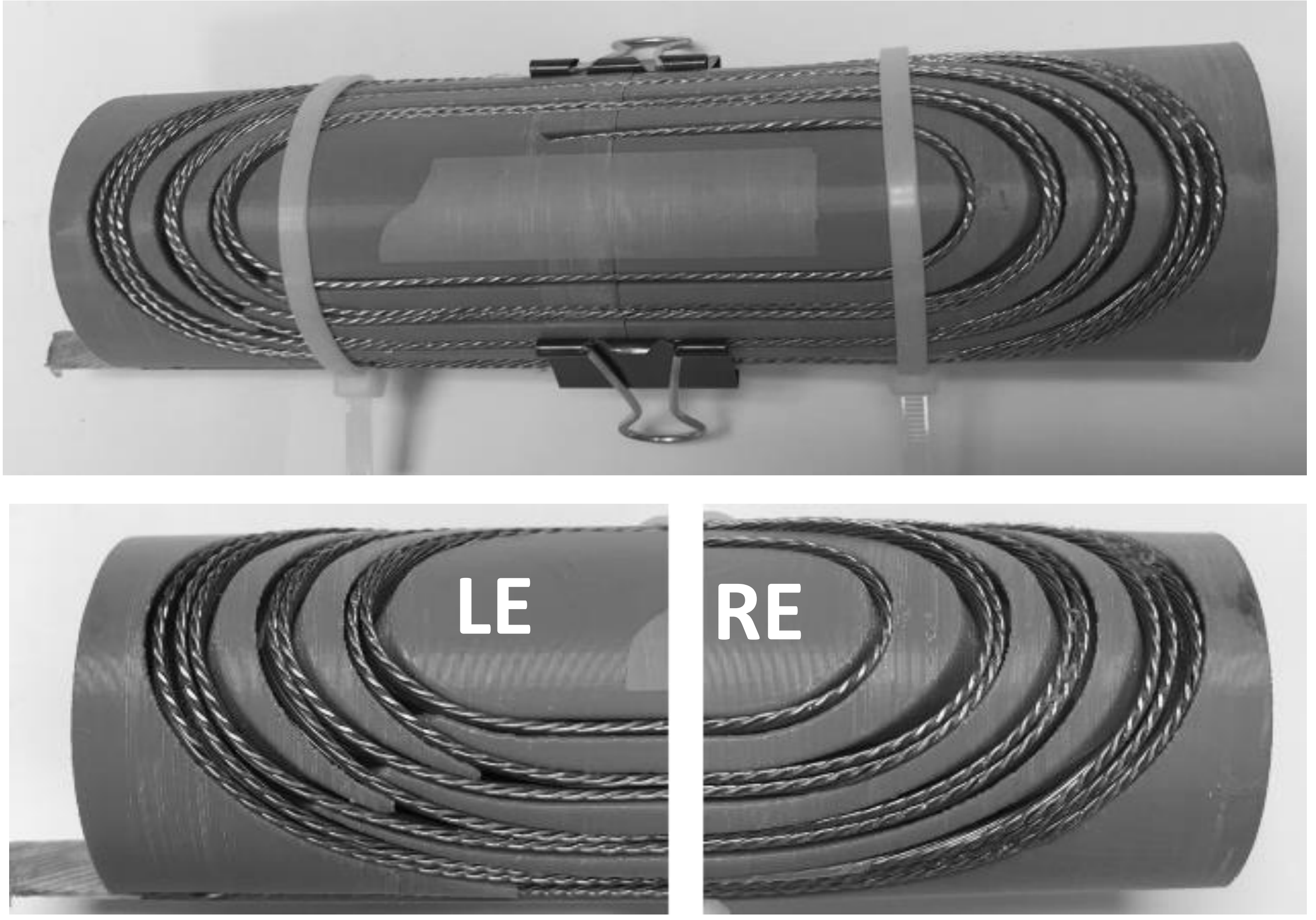
- 3D printed 3-piece part
- RE + straight section
- LE (short block transitions)
- Layer jump cap

- Several attempts with various cables – the best result with Cu cable
- OL: winding was OK, more difficult with multiturn mid-plane blocks
- IL: mid-plain turns lost stability (popped-up strands) in both end
  - limited space, mechanically unstable cable, no-insulation

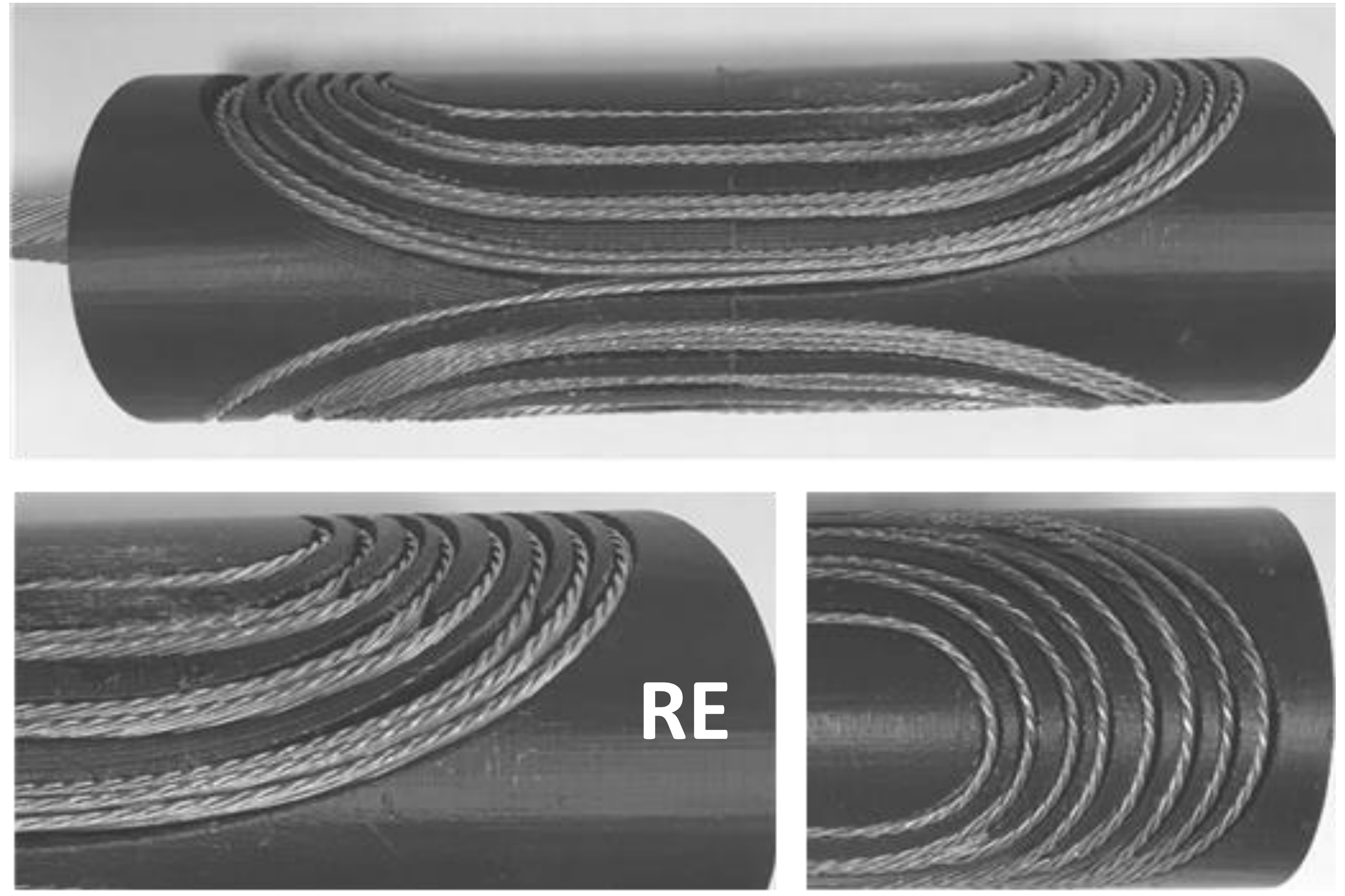
Design 1: IL practice winding with removable end spacers

Better but still hard to preserve cable stability in coil ends

Design 2: Single-layer practice coils with annealed Cu cable



Single-layer half-coil and whole coil



<= Single-layer half-coil and half-coil LE and non-LE (RE) views

- short inter-block cable transitions in the LE
- sizes of coil end blocks needs to be optimized to minimize the gaps between turns and structure

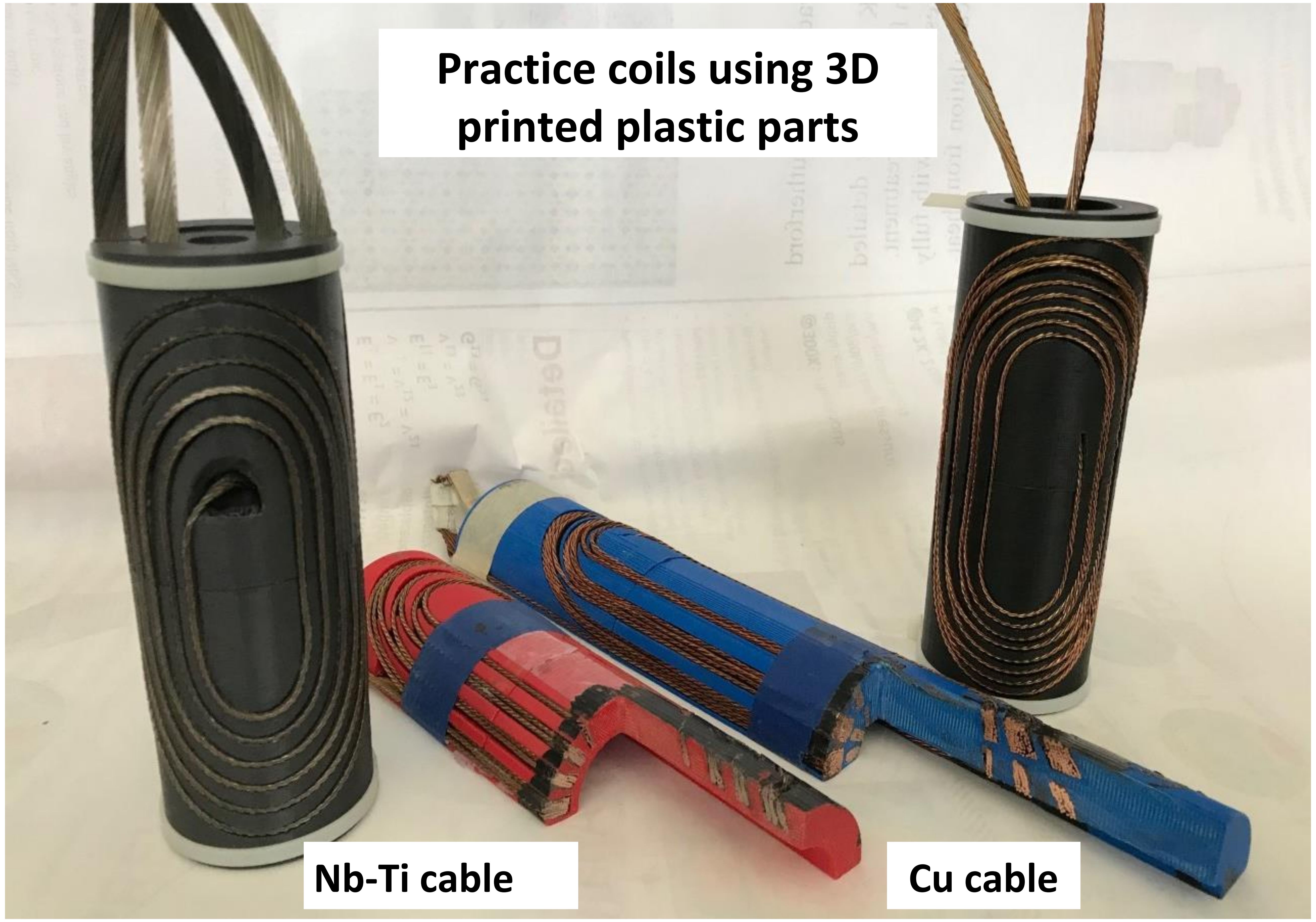
<= Single-layer dipole coil with a cable transition between the top and bottom half-coils and non-LE views of practice coil

- the last block in the LE fabricated without interturn spacers to compare two approaches to the coil end winding

Design 3: Double-layer practice coils with Nb-Ti cable

- Rigid Nb-Ti cable
- Separate structure fore each layer
- Both coil winding from outside
- Turns wound in separate groove
- One single IL coil w/o splice
- Separate OL half-coils
- **Good cable mechanical stability in both layers**
- **Good cable interlayer transition**

Summary



- Three designs of Bi2212 insert coil and SMCT coil support structure have been developed
- Several plastic models of the coil support structure have been made using 3D printing technology and "dummy" cable
  - important tool in the process of coil design and technology optimization
- Design 3 has been selected for the Bi2212 insert coil fabrication
  - we still need to finalize the cable insulation design and thickness to complete the coil engineering design
- The goal – to finish the design and start procurement in April 2023

Acknowledgment

We thank Jody Coghill for the design work and Steve Krave for 3D printing of coil plastic parts