A HIGH POWER DRIVING AND SELECTION FIELD COIL FOR AN OPEN MPI SCANNER

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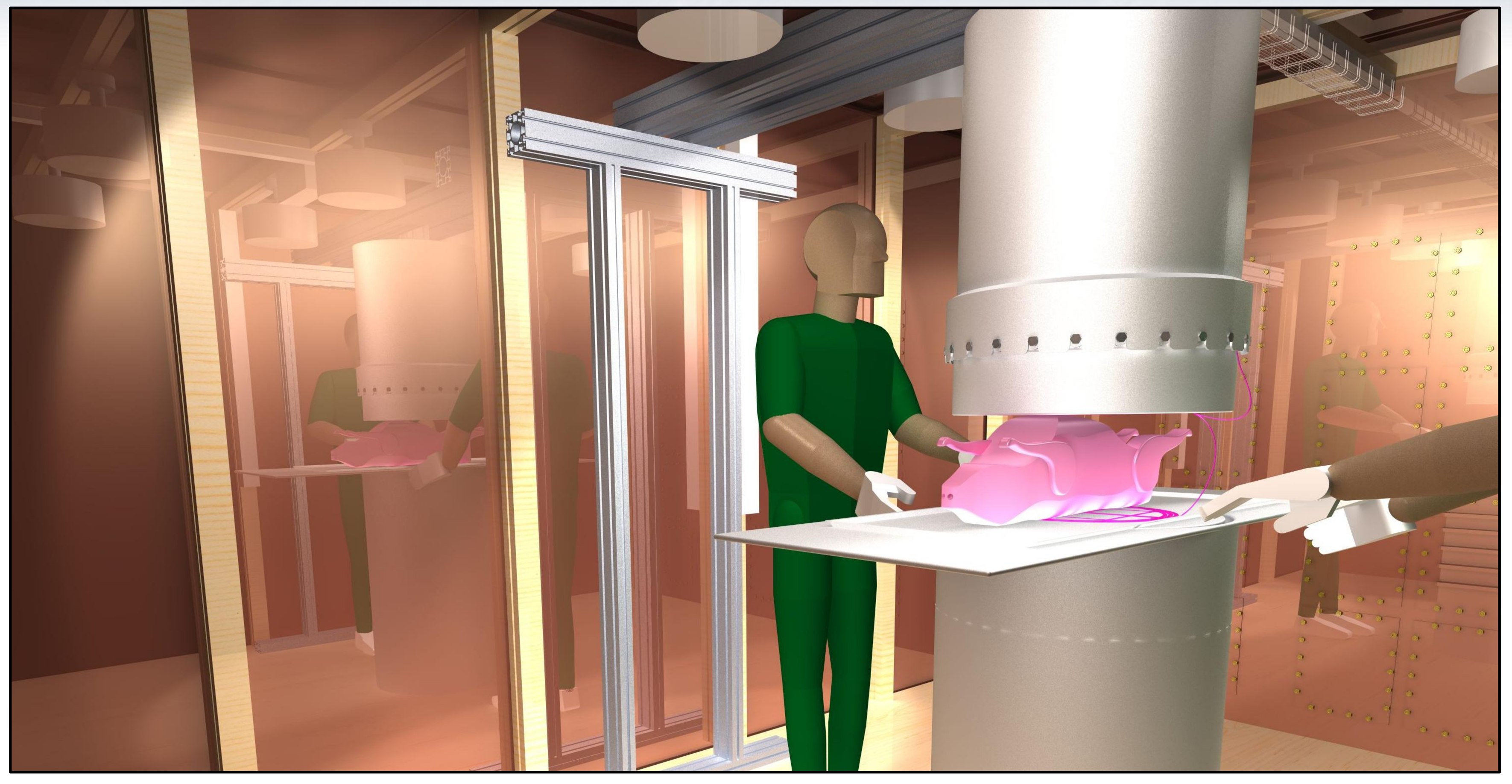


Volume repartition

The goal of the scanner is to keep a 360° access to the patient.

The selection field and the x drive fields are generated by the same coil sub-system in order to save space and avoid to have to shield the selection coil.
The y and z drive fields are generated using D shaped coils.

A single layer of cooling is used between each coil.

Kevlar composite, POM and PEEK are used to make the casing. A high Stiffness is required to guarantee the safe operating of the system with minimal material thickness.

The spaces above and under the scanner are used to install the capacitor bank required to run the system.

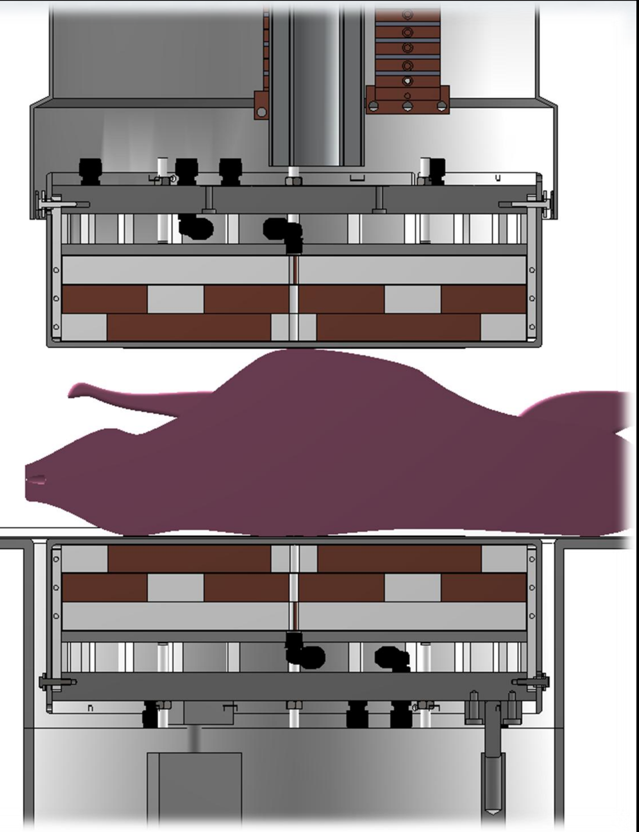


Figure 3 : Cross-section of the scanner.

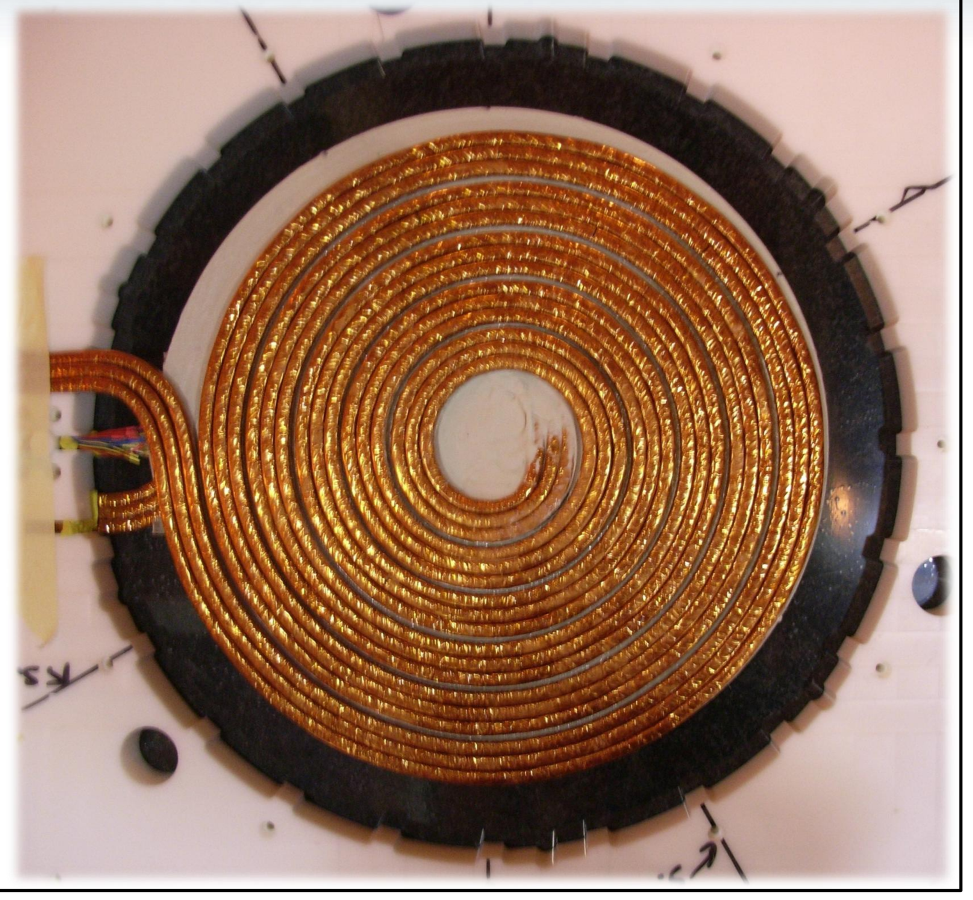
Fabrication

The coil and the casing have been cast on a high precision granite to limit the height variation of the cooling channel.

An epoxy with an high thermal conductivity (Durapot 865, Cotronics, USA) have been used to make the spacer of the coil and fill the air gap between the wire.

3 parallel square Litz wire have been used to form the conductor (Custom product, Sofilec, France).

The fabrication took 4 weeks, once all the components were available. 38 temperature sensors were also build-in.



Imaging goal

The imaging goal for the scanner is to scan the heart of a Göttingen mini pig. 10 Month old mini pigs have been chosen as patient according to their chest height when they are lying in the supine position. The table 1 summarize the data used to make this choice.

The field of view have to cover the whole heart, which have a volume of approx. 50x50x70 mm³. The resolution has to be in the mm range in order to resolve correctly some blood vessel, as the one presented in the table 2.

Table 1 : Measurements done on Göttingen mini pigs to define our patient.

Age / month	Measured Animals	Weight /Kg	Sexe	Chest Height / cm
5 and 6	11		M & F	14-16
6 and 7	6		M & F	16-18
10	1	17-20	F	18
12	6	24-33	M & F	20-25

Table 2 : Vessel diameter [1] for 12 month old mini pigs.

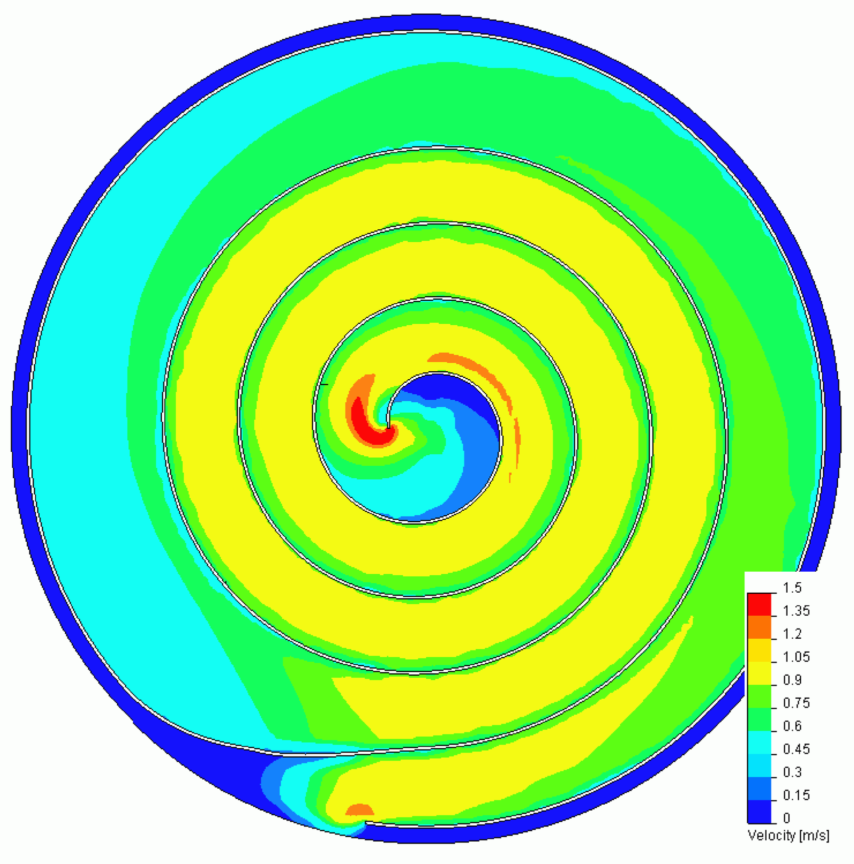
Vessel	Diameter /mm			Length /mm
	min	max	mean	
A. Aorta ascendens	12,7	18,9	15,6	55,3
V. jugularis ext.	8,8	13,4	10,2	87,3

Cooling study

The coils are cooled via 4 surfaces. As the maximum pressure inside the scanner is limited to a few bars, a laminar water flow was chosen to dissipate the heat produced by the coils.

A channel with a width of 50 mm, a height of 1.5 mm and a length of approx. 5 m is made on each surface with the help of a snail shaped structure.

On the presented coil, a flow of 2.5 l/min with a dynamic pressure of 0.8 bar is used to reach a mean velocity of 0.7 m/s, which is required to cool the 5 kW of power dissipated by the coil.



Validation

A power of 5 kW were applied to the coil, with a DC current of 800 A. The inner temperature of the coils increased to a maximum temperature of 185 °C. At 20 °C, the coil resistance is 4.5 mOhm. At 185 °C it is of 7 mOhm.

The coil was stable at 185 °C for around 15 minutes. The coil surface was below 100 °C. Unfortunately, the connectors were desoldered after 15 minutes, due to the combination of mechanical and thermal constrains.

The means thermal conductivity of the coil have been calculated to be around 1 W/(m.K). This is surprisingly close to the thermal conductivity of the epoxy itself, measured to be around 1.15 and 1.25 W/(m.K) (courtesy of Bruker Biospin Wissembourg, France). Indeed, as is shown on the left part of figure 6, the coil include a lot of air bubbles.

Finally, a first low power AC test has been done on the coil. It appears, has showed on figure 6 in the middle, that the signal in the different parallel wire of the coils are not in phase nor of the same amplitude as the send signal. This effect has still to be studied.

Fields definition

Selection field

The selection coil have to generate a field of:

- 1.0 T/m in the x direction,
- 0.5 T/m in the y and z direction.

The resolution [2] will be (using 50 nm SPIO.):

- 0.5 mm in the x direction,
- 1.1 mm in the y and z direction.

Drive fields

The drive coils generate a field of :

- +25.0 / -25.0 mT in the x direction,
- +12.5 / -12,5 mT in the y direction,
- +17.5 / -17.5 mT in the z direction.

PNS/SAR thresholds

Using field in the 25 kHz range shouldn't cause any safety issue on the mini pigs.

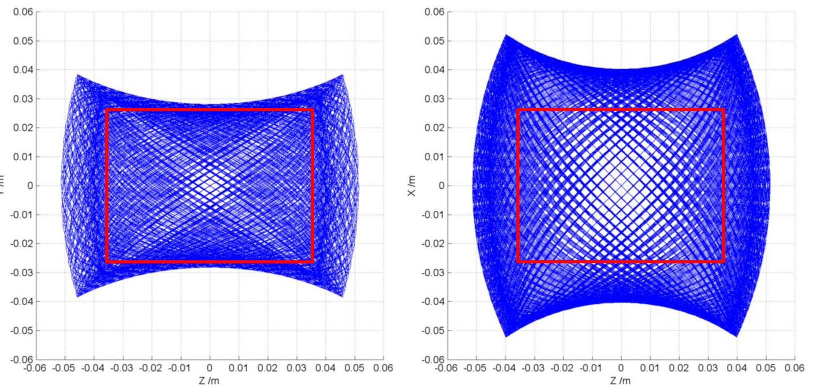


Figure 1 : In red : minimal imaging volume. In blue : actual trajectory of the FFP.

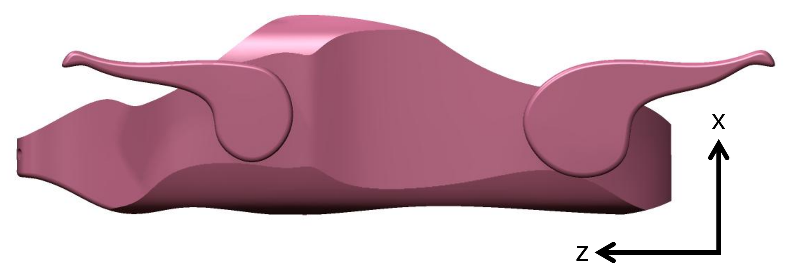


Figure 2 : Model of a mini pig showing the scanner's direction used on this poster.

Electric field

Due to the high inductance of the coil, high voltage are generated during a scan. Those high voltage together with the presence of air bubbles between the conductor may lead to partial discharge (PD).

Two main issue arise from the PD :

- Noise generation from the sparks,
- Mechanical destruction of the insolation.

Figure 4 : The winding planning of the x driving coil. In order to decrease the voltage across the coil, 3 wire are winded in parallel. A distance of 2 mm is kept between the layer to prevent any PD.

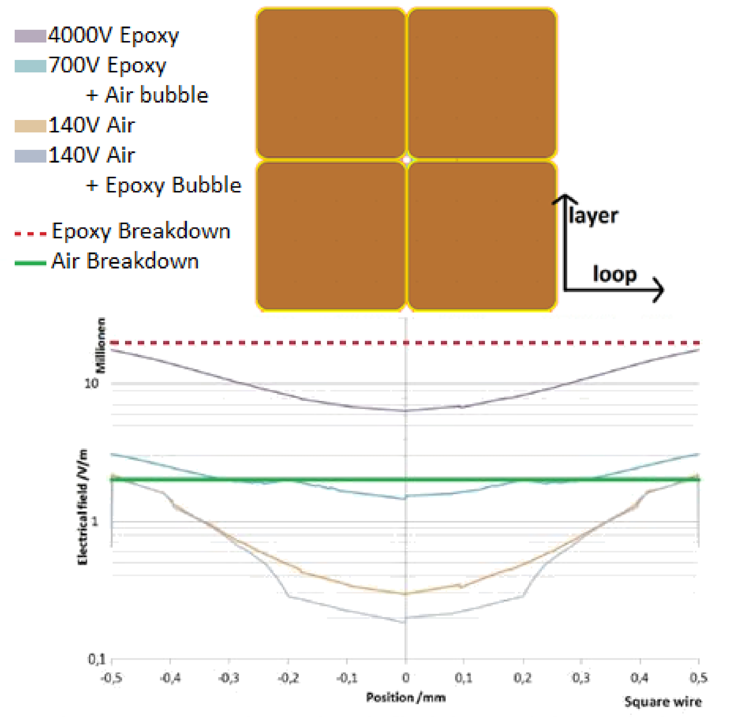
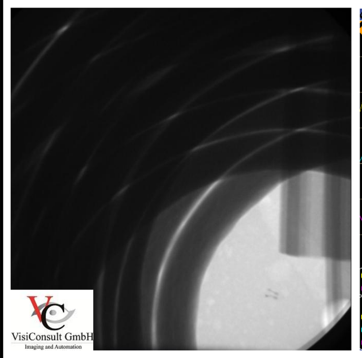


Figure 5 : Electrical field and breakdown voltage between two layers of a coil made with a square Litz wire with a side of 7.3 mm and a bubble in the middle.



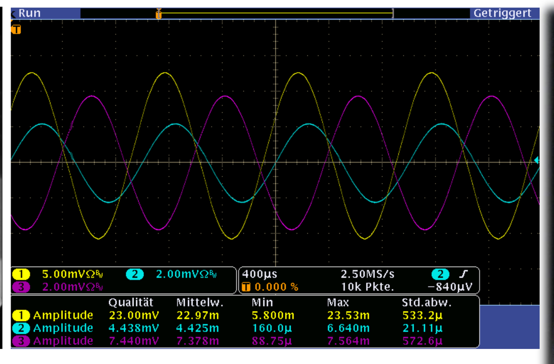


Figure 6 :

Left : X-ray view through the coil. A lot of bubbles can be seen (courtesy of VisiConsult GmbH, Germany).

Middle : When a single signal is send through the 3 parallel wires, this is how the signal spread up in each single wire.

Right : View of the finished coils.

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