

# THE FAIR SIS100 BUNCH COMPRESSING RF STATION

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## Abstract

In the frame of the Facility for Antiproton and Ion Research (FAIR) 9 bunch compressor RF stations were ordered for the first stage of realization of the SIS100 synchrotron [1]. For RF gymnastics referred to as bunch rotation, one RF station has to provide a sudden rise in gap voltage of up to 40 kVp within less than 30  $\mu$ s. The system is designed for a maximum RF burst of 3 ms per second. The RF frequency will be pre-selectable between 310 kHz and 560 kHz at a harmonic number of  $h=2$  with respect to the beam. Compressed bunches with a peak current > 150 A and a width < 50 ns are the goal. For this purpose, a 1.218 m long cavity was designed using iron-based magnetic alloy cores. Variable vacuum capacitors are attached for tuning. The cavity is driven by a cross-coupled push-pull tetrode amplifier. This scheme minimizes the influence of the tetrode's DC current at the working point to the cores. The energy for the pulsed system is stored in a relatively small capacitor bank which will be charged semi-continuously and a voltage-stabilizing device is added. Cavity and power amplifier were realized by AURION Anlagentechnik GmbH – the power supply unit is designed and built by OCEM Power Electronics.

## General Data

Item	from	to
Frequency Range	310 kHz	560 kHz
Harmonic Distortion		-26 dBc
Nominal Voltage	1 kV	40 kVp
Amplitude Rise Time		$\leq 30 \mu$ s
Burst Length	0 ms	3 ms
Shunt Resistance		$\leq 2 \text{ k}\Omega$
DC Beam Current		$\leq 1.2 \text{ A}$
Bunch Peak Current		$\leq 150 \text{ A}$
Compressed Bunch Length		30 ns

## Cavity Design

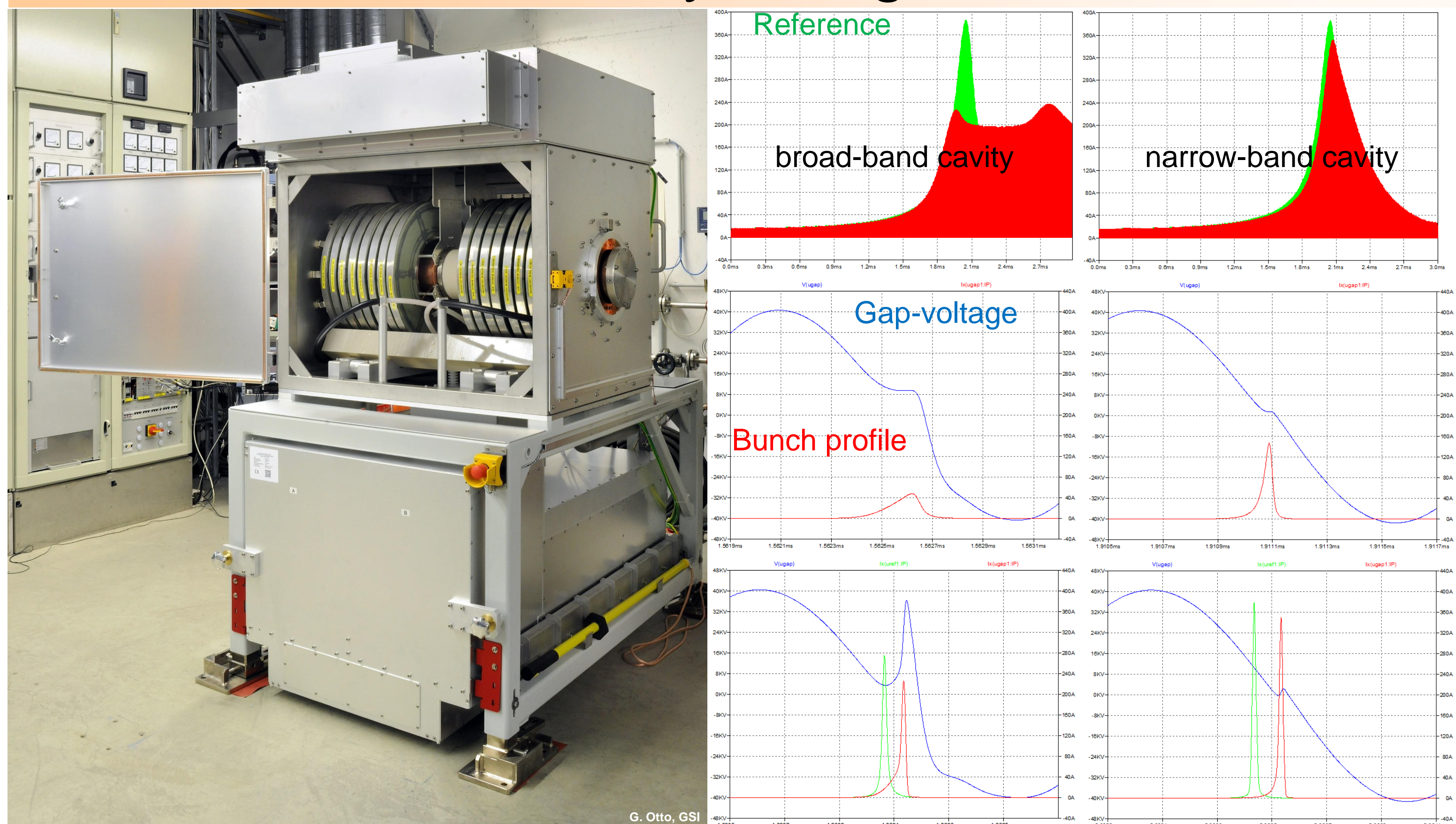


Figure 1: Fully assembled bunch compressor

Figure 2: Simulated bunch rotation – beam currents over time

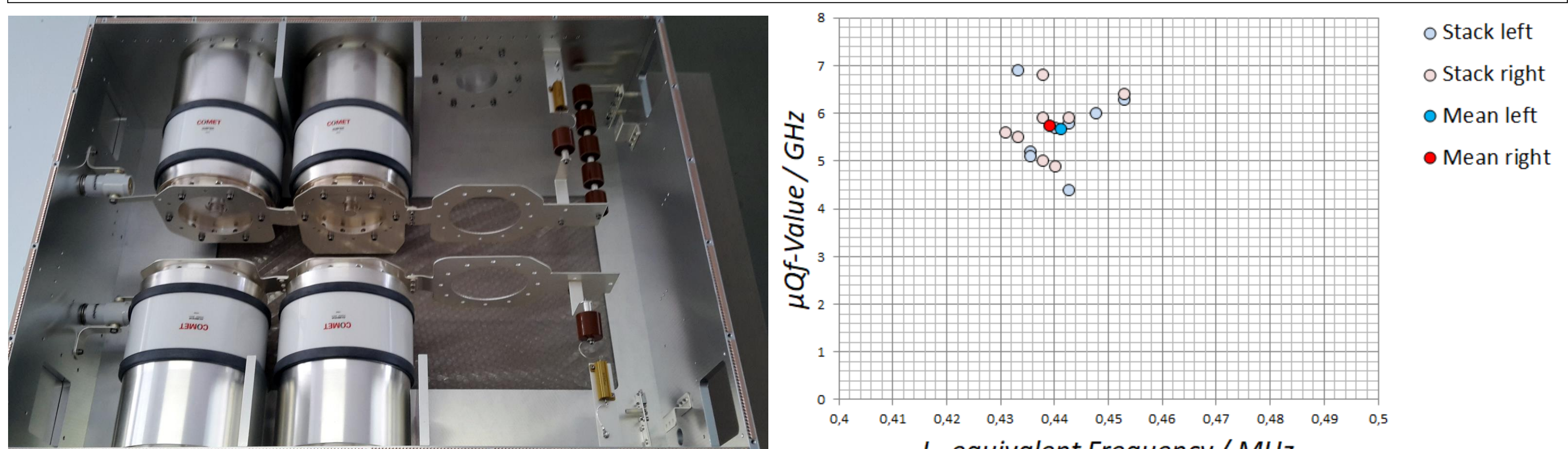


Figure 3: Performance of the individual toroids

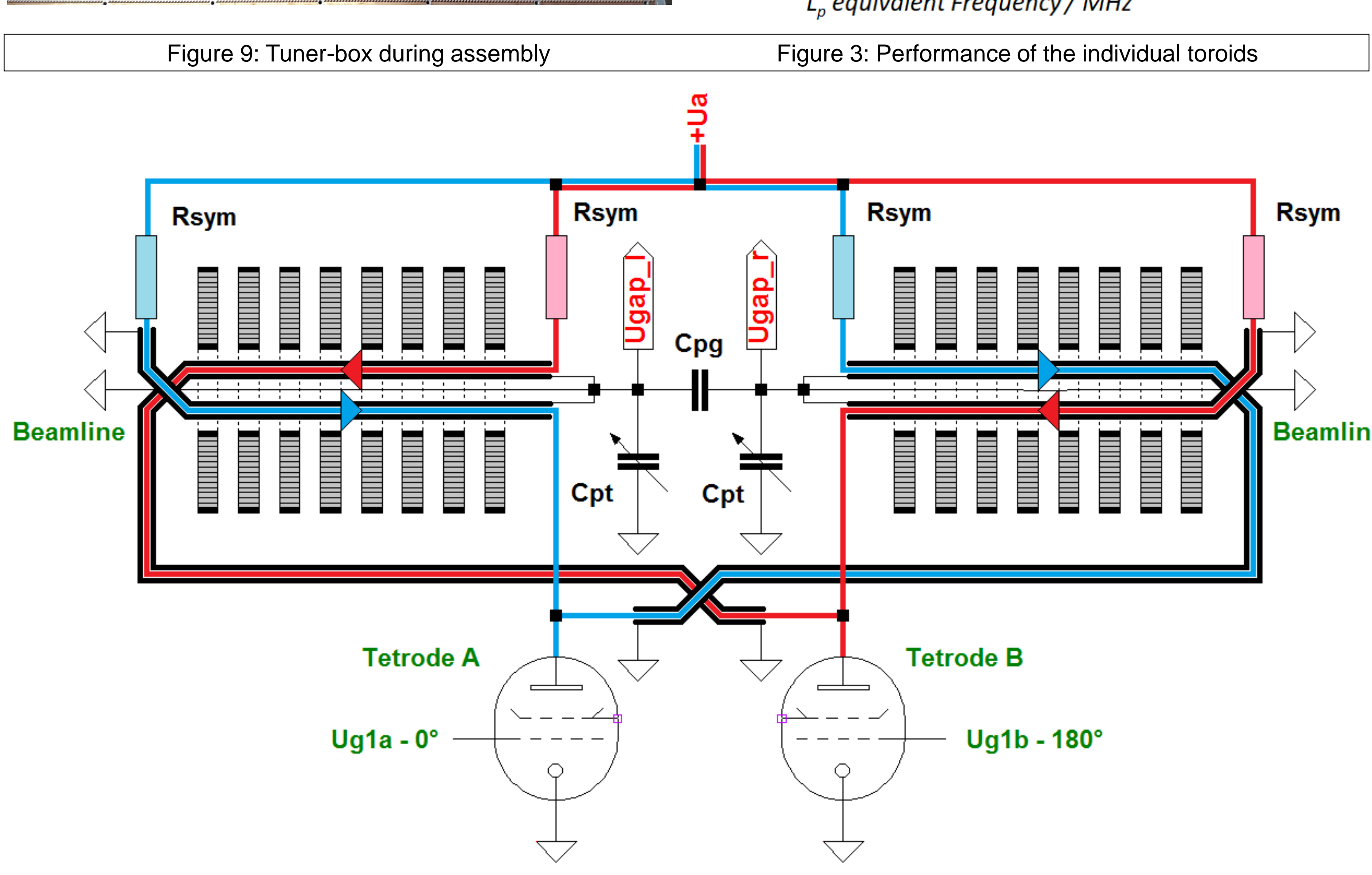


Figure 4: Cross-coupling scheme

## Amplifier

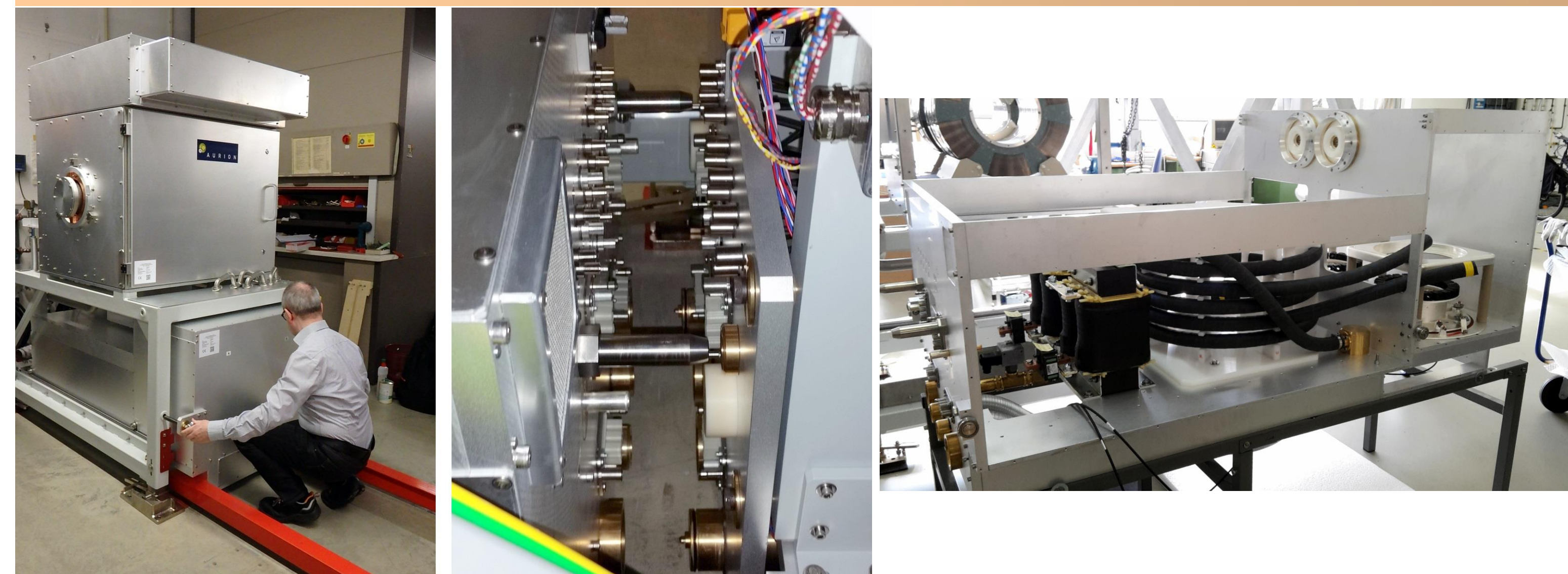


Figure 5: Undocking the amplifier (left) & contact plates at the rear (right)

Figure 6: Amplifier during assembly

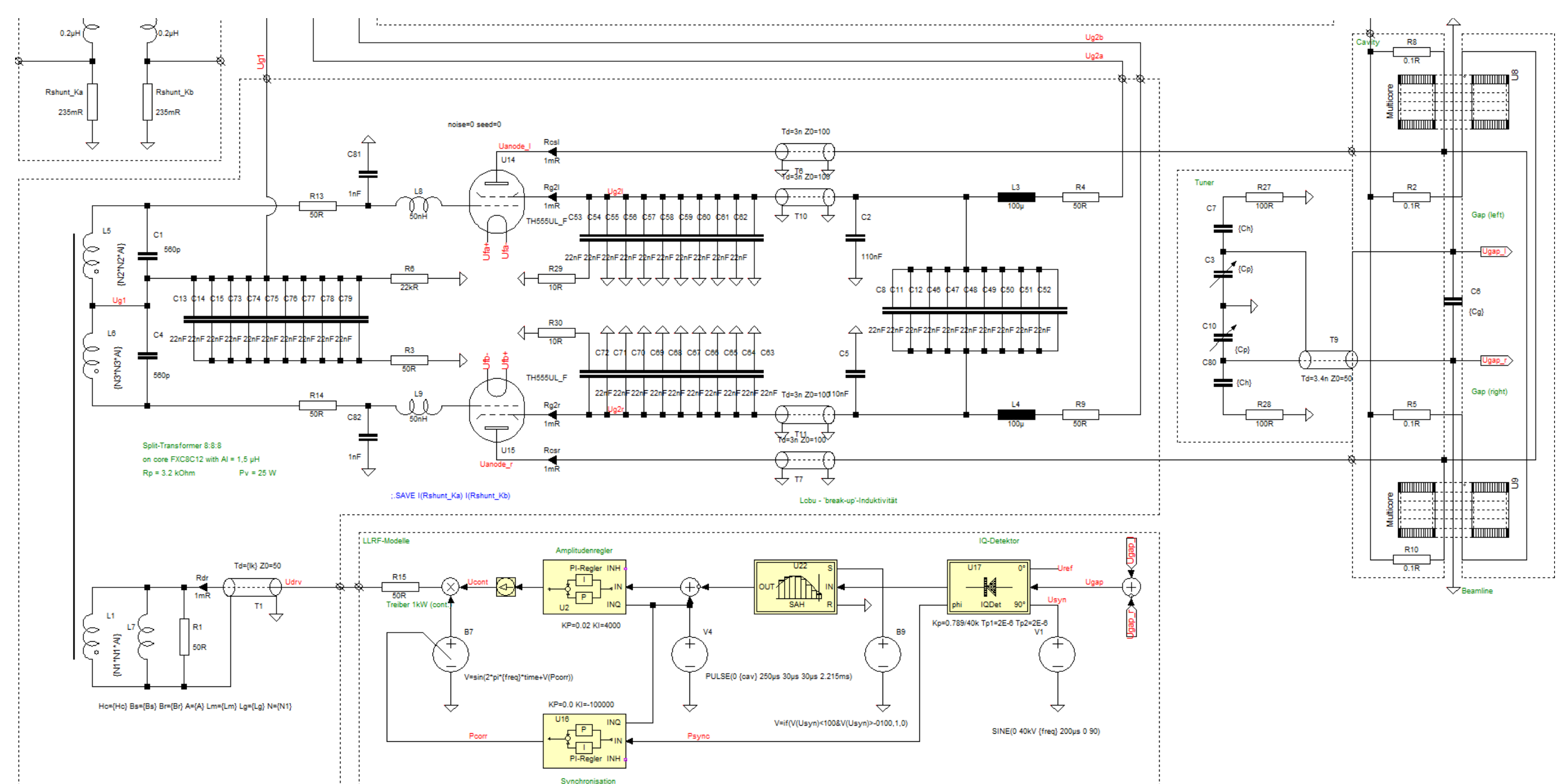


Figure 7: System simulation with LTspice (cutout – cavity, amplifier, LLRF) during design phase

## Power Supply Unit (PSU)

Power Supply	Voltage	Max. Current
Anode	20 kV <sub>dc</sub> to 27 kV <sub>dc</sub>	100 A (3.2 ms)
Screen Grids	2000 V <sub>dc</sub> (x 2)	4.0 A (3.2 ms)
Control Grid	-800 V <sub>dc</sub> to -100 V <sub>dc</sub>	1.0 A
Filaments	400 V <sub>ac</sub> (x 2)	16 A

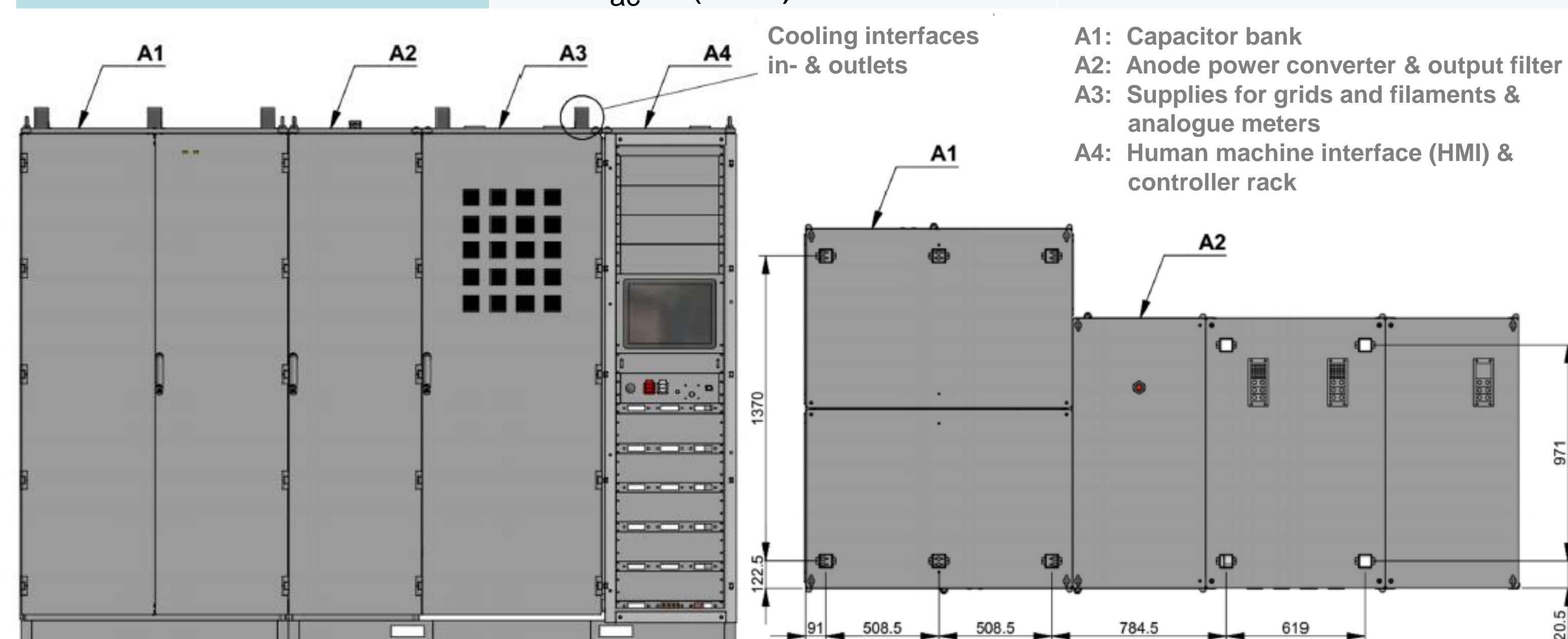


Figure 8: Mechanical layout of the power supply – front and top view

## Commissioning Results

- The gap voltage of 40 kV<sub>p</sub> was achieved over 400  $\mu$ s (burst duration limited by the SIS18BC PSU).
- Tuning and operation was confirmed over the full frequency range.
- The rise time requirement was fulfilled.
- Thermal stability of the cavity was shown by CW heating, applying a 2 kW RF driver amplifier.

## Conclusion and future Steps

The modified SIS18 design was verified with success and most of the desired SIS100 requirements were met already. The new MA core material supplied by MAGNETEC GmbH was qualified for cavity applications. One of the next steps will be the integration of the new PSU - whose completion is imminent - making the proof of full length RF bursts (3 ms) possible. A 12 h endurance test is foreseen to complete the commissioning phase within the next months. One bunch compressing RF station will remain in our testing premises to perform ongoing experiments for optimising our LLRF components and to establish operation readiness.

## References

- [1] H. Klingbeil et al, "Status of the SIS100 RF Systems", in Proc. IPAC'17, Copenhagen, Denmark, May 2017, paper THPIK016, pp. 4136-4138.
- [2] P. Hülsmann, R. Balss, U. Laier and H. Klingbeil, "Bunch Compression for FAIR", in Proc. PAC'09, Vancouver, BC, Canada, May 2009, paper TU5PFP023, pp. 864-866

