This project has received funding from the European Union's Horizon 2020 Research and Innovation programme under GA No 101004730.

WP13: New RF Amplifiers based on GaN Semiconductors

IFAST Kick-off Meeting / 2021 05 04

Dragos Dancila (Uppsala University - FREIA)

WP13: New RF Amplifiers based on GaN Semiconductors

- Realisation and evaluation of a new RF amplifier based on GaN semiconductors at kilowatt level.
- Identification of the advantages of GaN semiconductor technology for accelerator RF amplifiers.
- Specifications
  - 1000 W combined output power
  - 750 MHz
  - High efficiency >70%
  - High breakdown voltage
  - GaN transistors from e.g. Ampleon, Qorvo, Cree - Wolfspeed, NXP Semiconductors, Infineon, etc.
- D13.3: GaN RF amplifier module at kW level.

Example of RF amplifiers developed at the FREIA laboratory Uppsala University, Technological Platform in AMICI.

It takes a handful of transistors (200) to replace one tetrode of 200 kW

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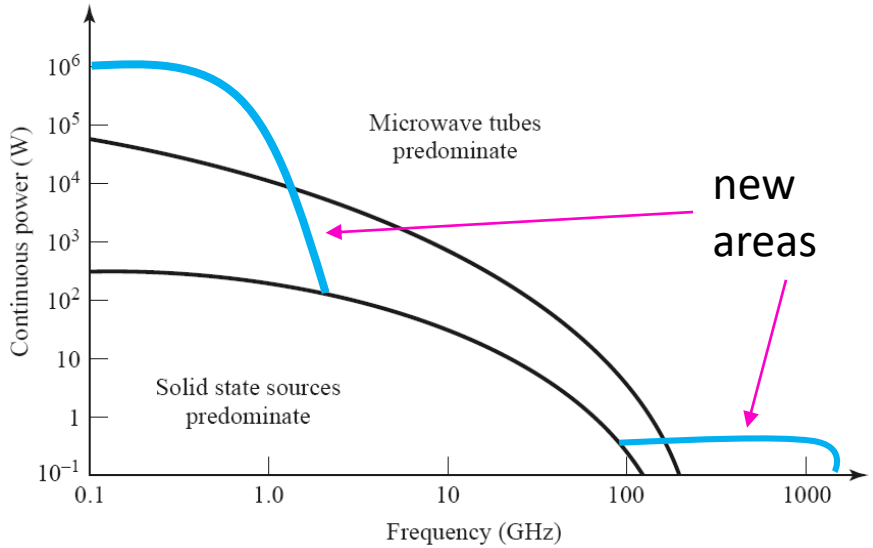
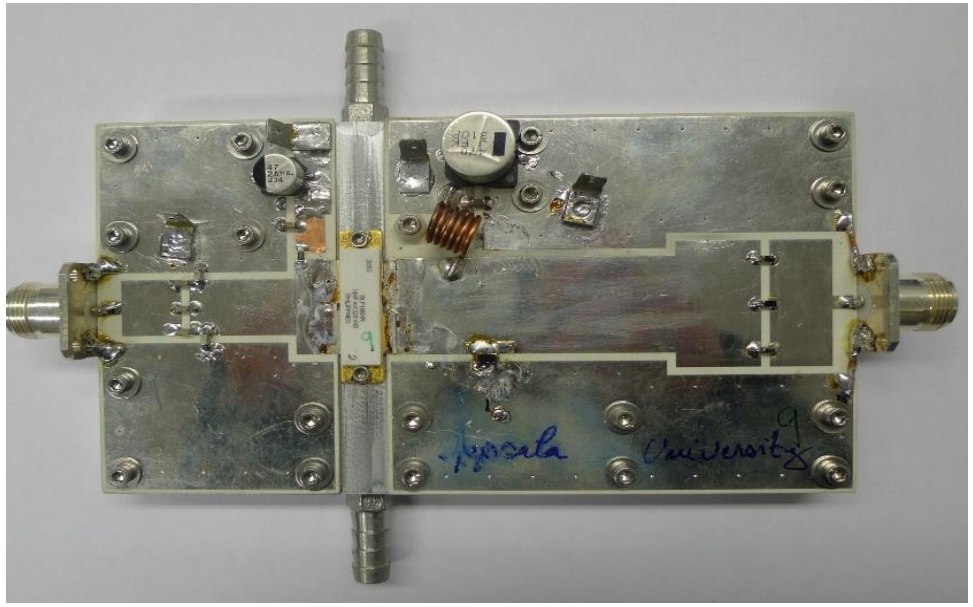
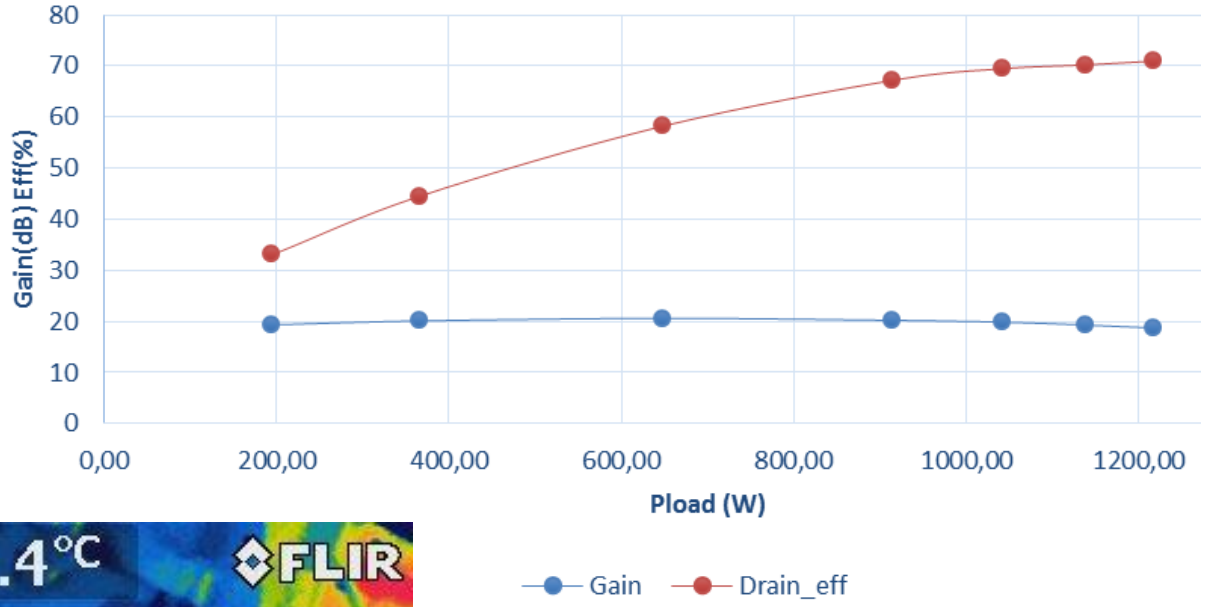
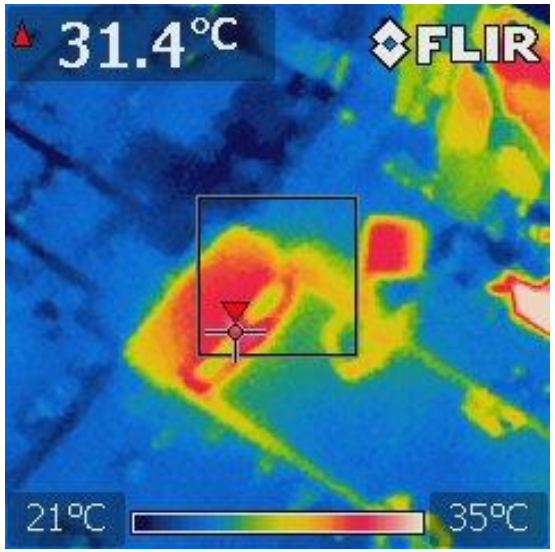


Single ended RF power amplifier 352 MHz 1.25kW 70% efficiency

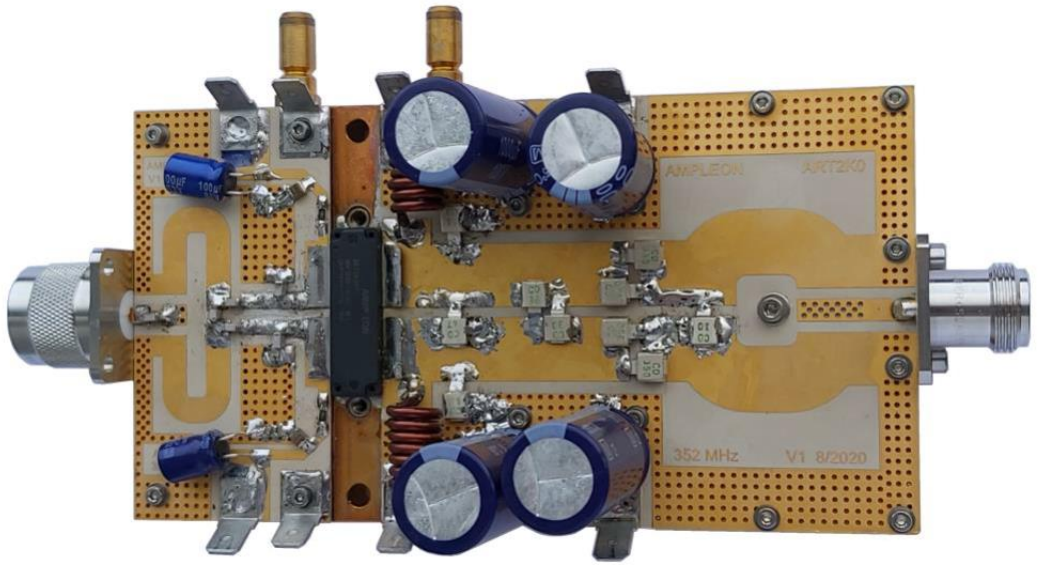




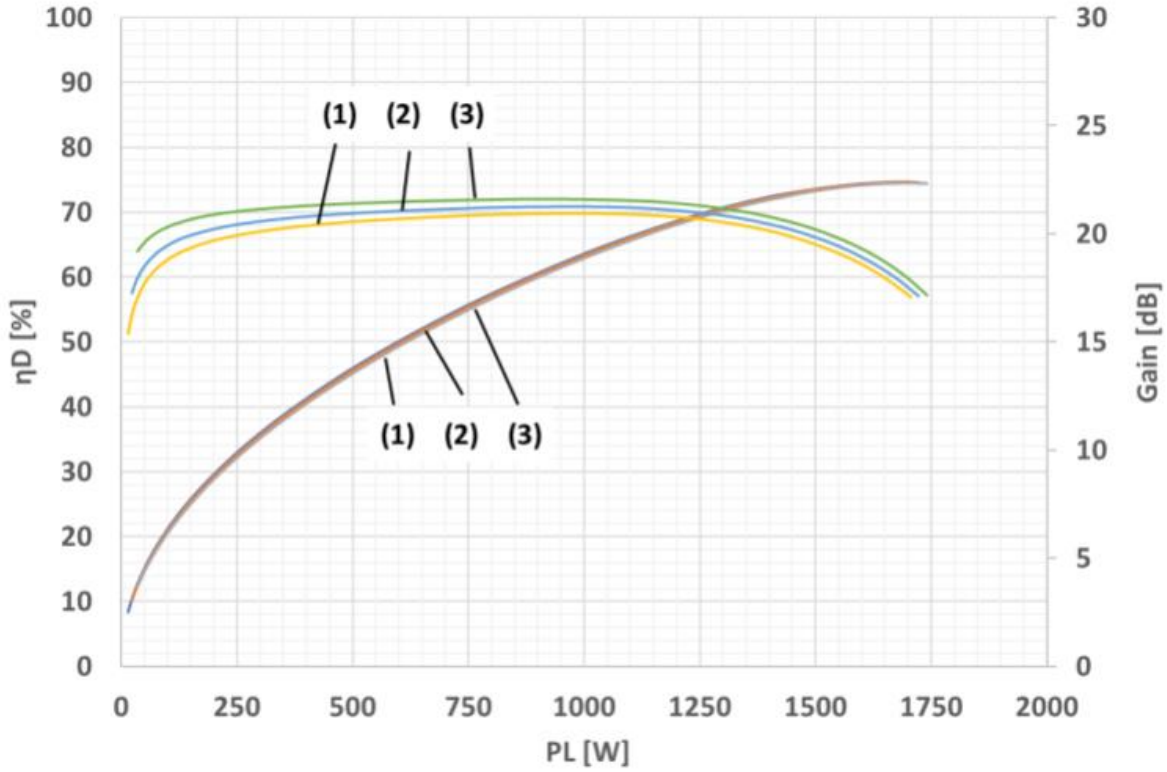


L. Haapala, A. Eriksson, L. D. Hoang and D. Dancila, “Kilowatt-level power amplifier in a single-ended architecture at 352 MHz,” 2016, Electronics Letters, Vol. 52, no 18, p.1552-1553.

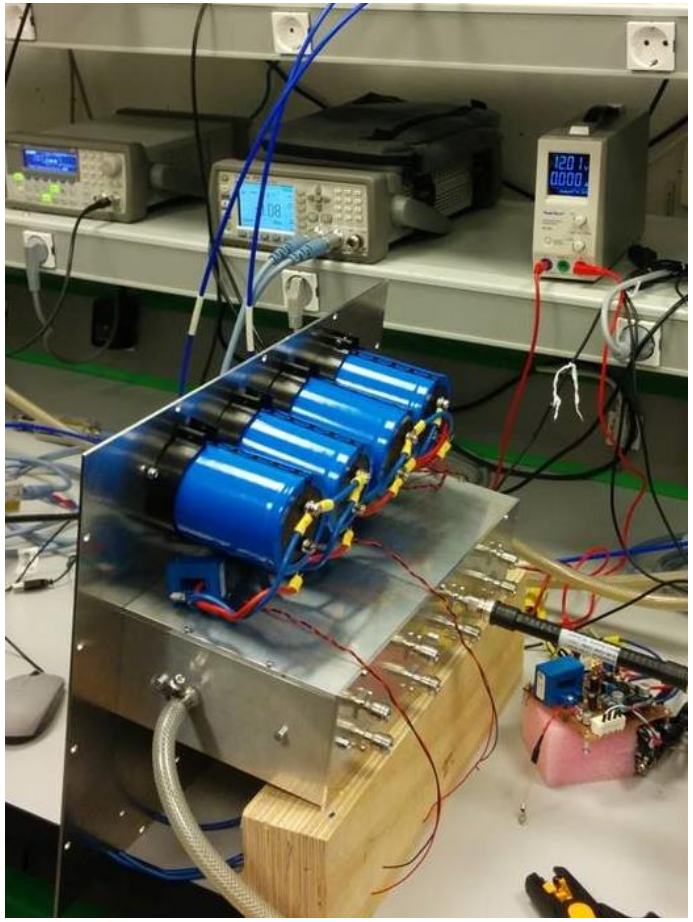
Towards industrialization: ART2K0PE board at 352 MHz 1600 watt CW efficiency of more than 74 %

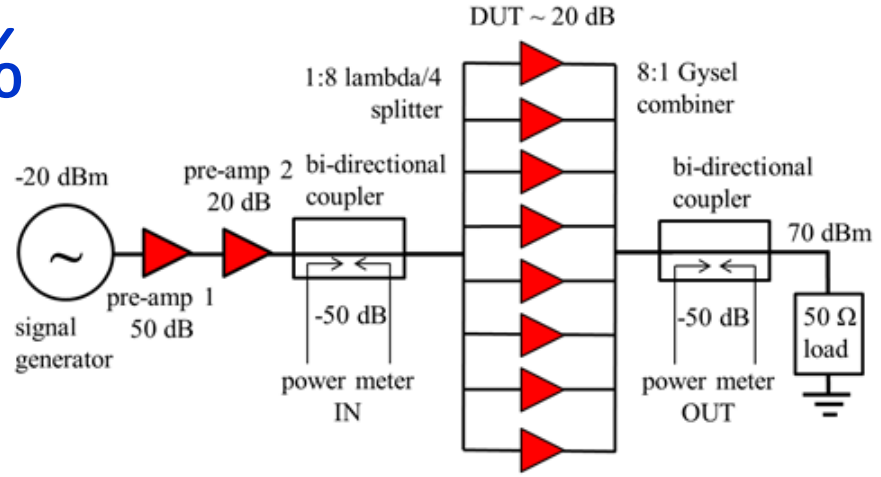


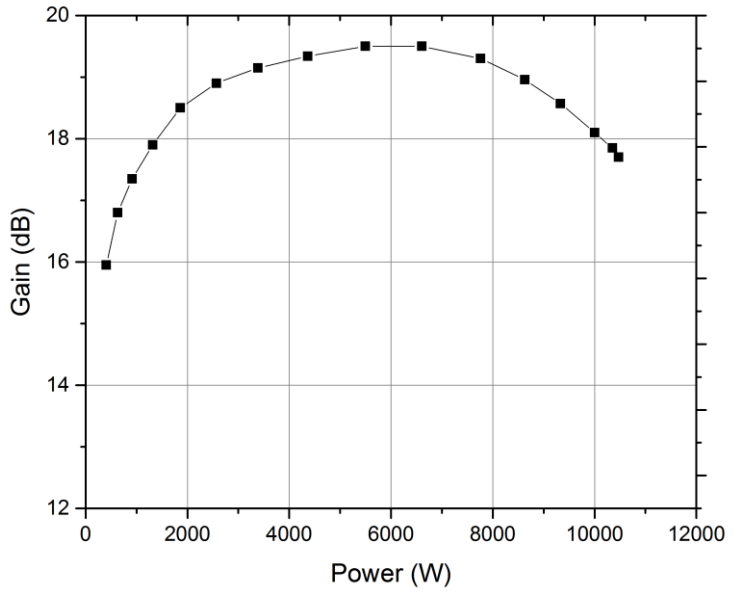
ART2K0PE: Ampleon Power LDMOS transistor



10 kW HPA 352 MHz pulsed 5%

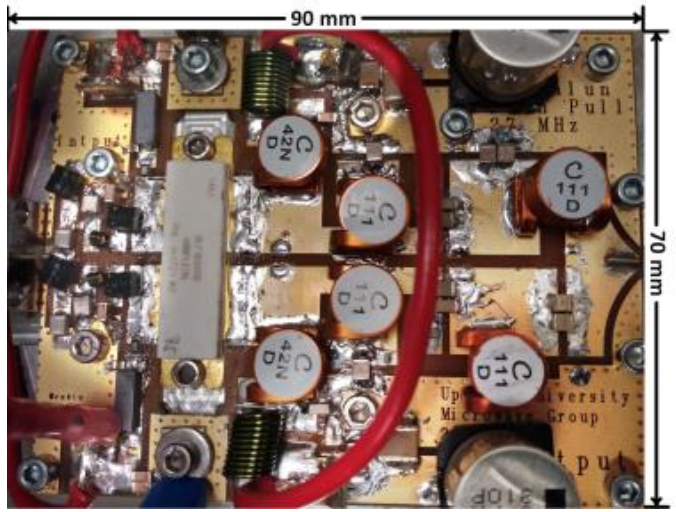


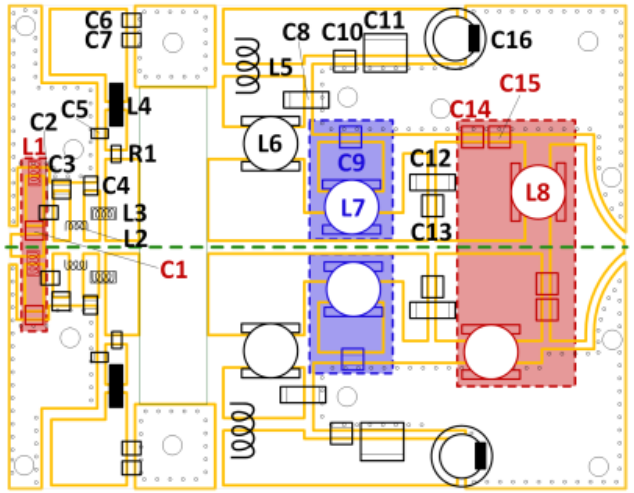


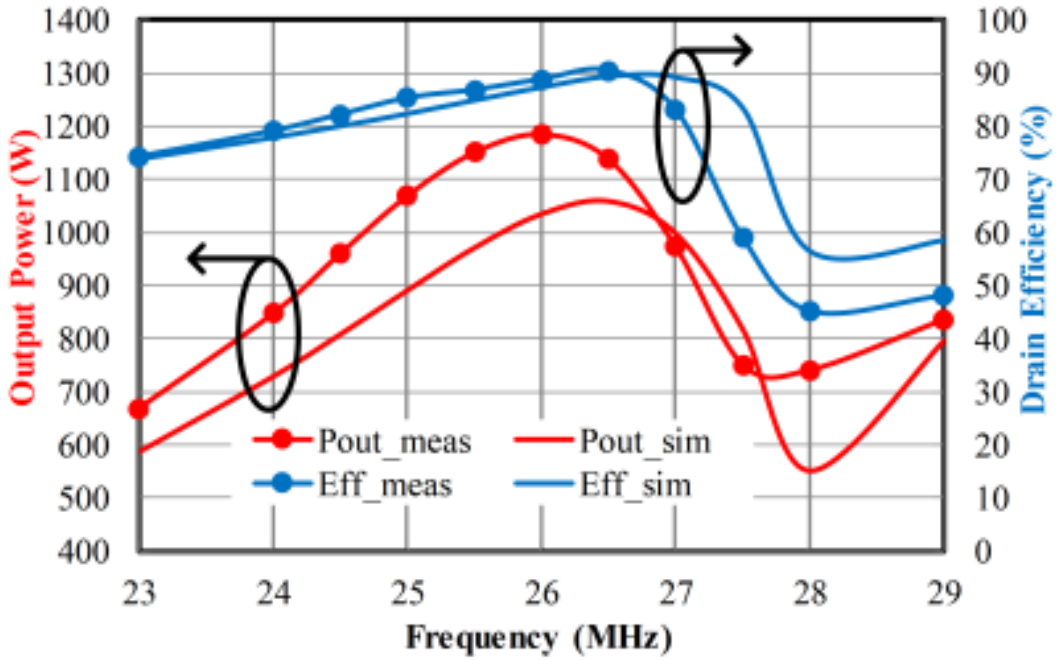


D. Dancila et al, "A compact 10 kW solid-state RF power amplifier at 352 MHz," 2017 IOP Conf. Series: Journal of Physics: Conf. Series, vol. 874, 012093

SSPA at 27 MHz – 1kW efficiency of 90% (non linear class E – lumped push-pull)

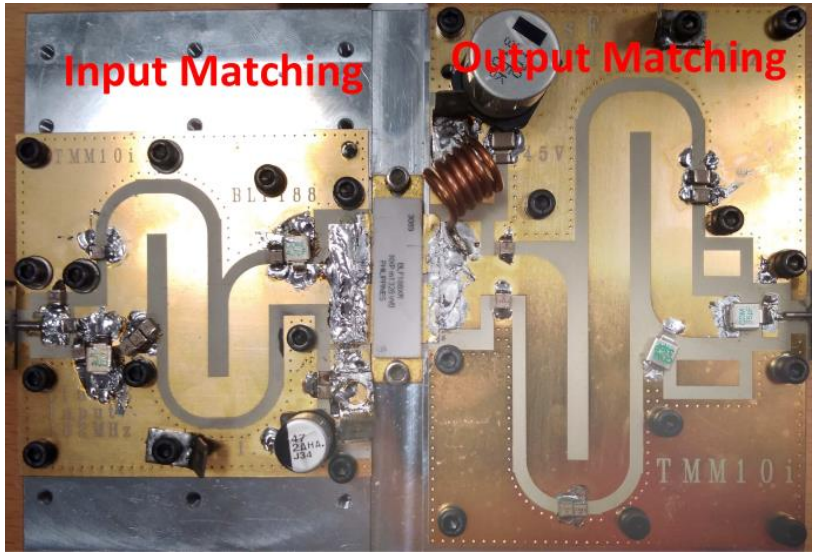


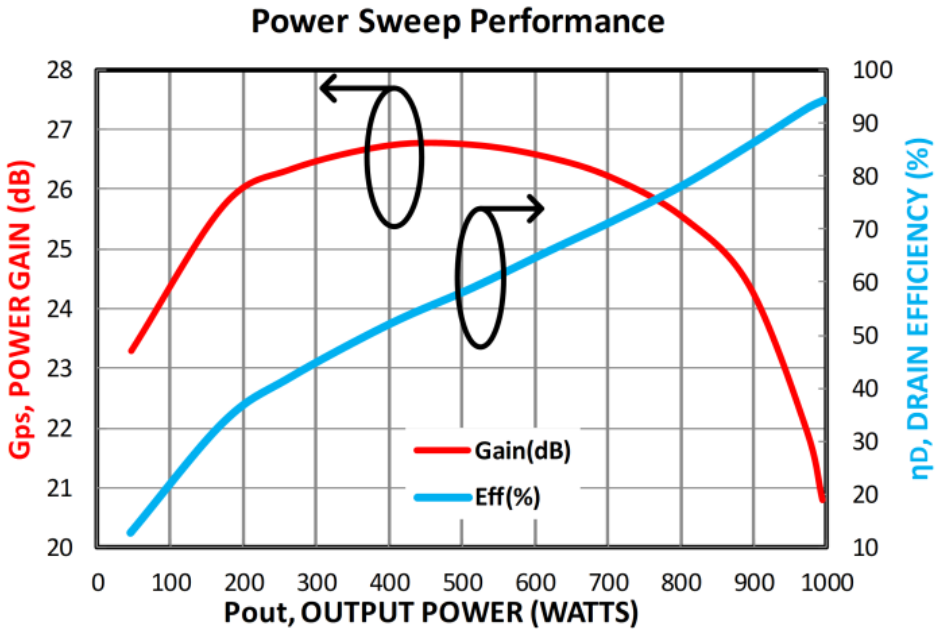


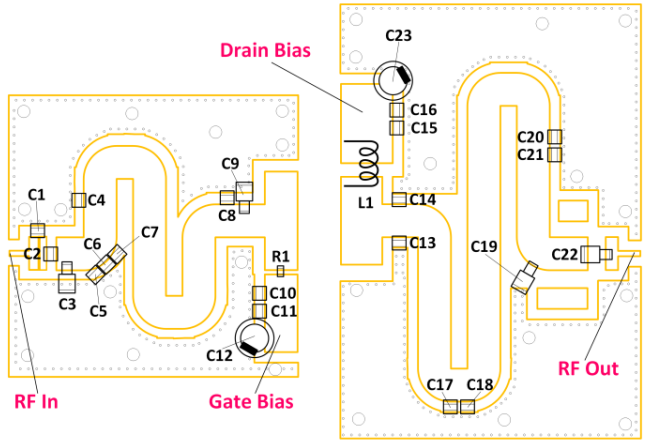


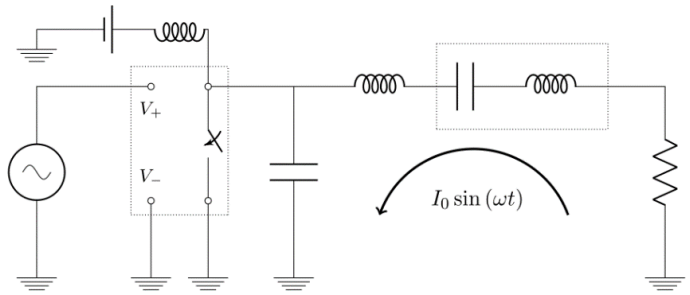
R. Tong and D. Dancila, “Compact and Highly Efficient Lumped Push-pull Power Amplifier at Kilowatt level with Quasi-static Drain Supply Modulation” in IEEE Transactions on Microwave Theory and Techniques, 2020.

SSPA class E at 100 MHz – 1kW efficiency of 93%



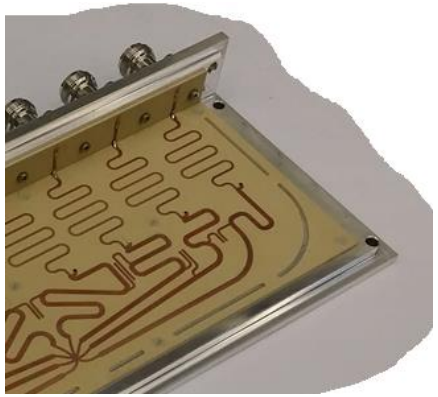


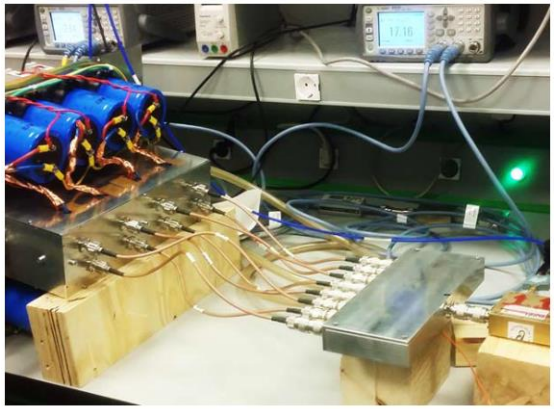




R. Tong, O. Bengtsson, A. Bäcklund and D. Dancila, "*Highly Efficient Kilowatt Power Amplifier Module as RF Source for Radioisotope Production Cyclotron System", IEEE Journal of Microwaves* 2020.

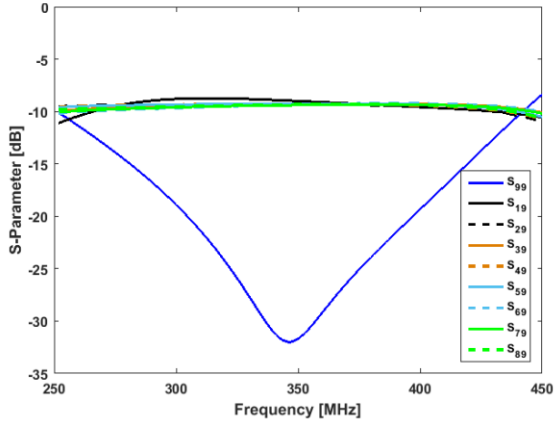
Gysel Power Combiner 10 kW at 352 MHz

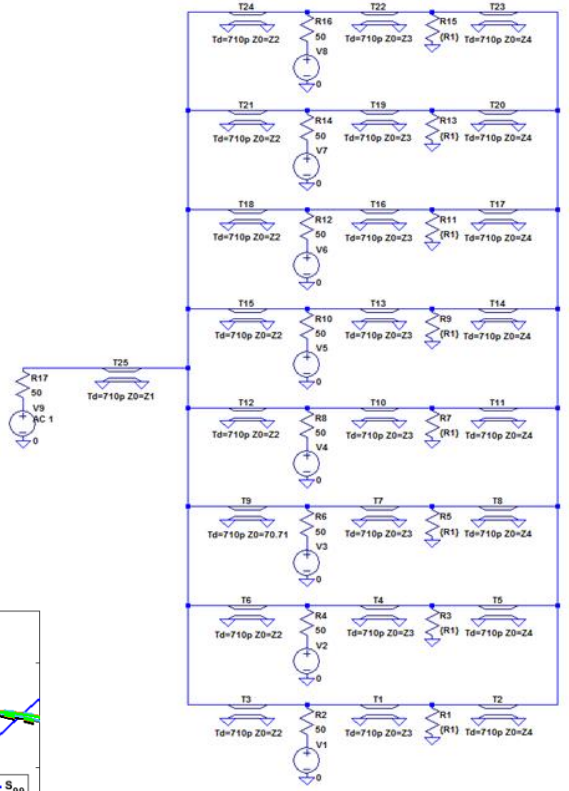


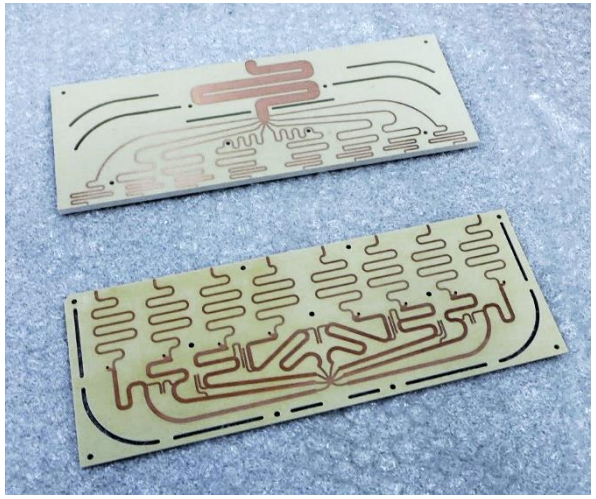


Key Parameters

- S_{NN} < -20 dB
- Losses < 0.1 dB
- High Power Handling
- 240 x 100 x 30 mm

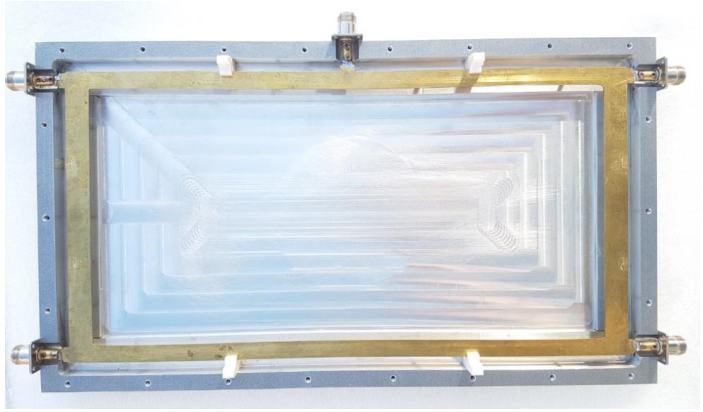


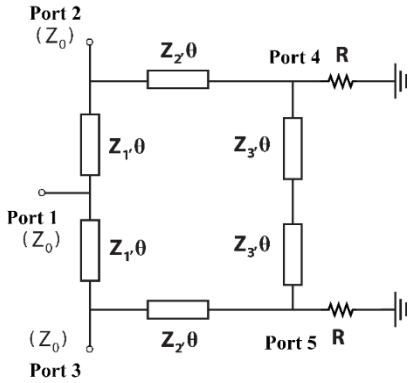


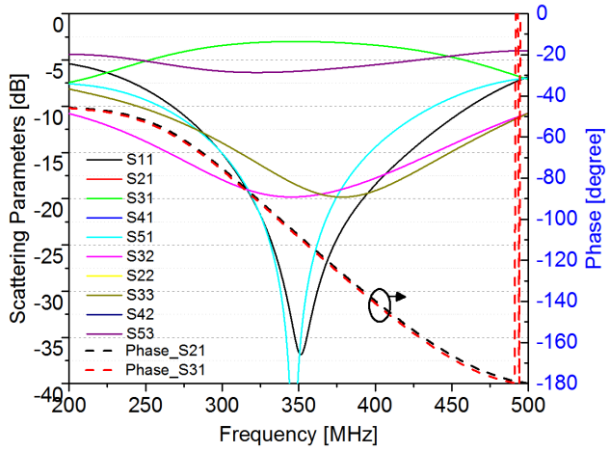


M. Jobs, D. Dancila, J. Eriksson and R. Ruber, "An 8-1 Single-Stage 10-kW Planar Gysel Power Combiner at 352 MHz," in *IEEE Transactions on Components, Packaging and Manufacturing Technology*, vol. 8, no. 5, pp. 851-857, May 2018.

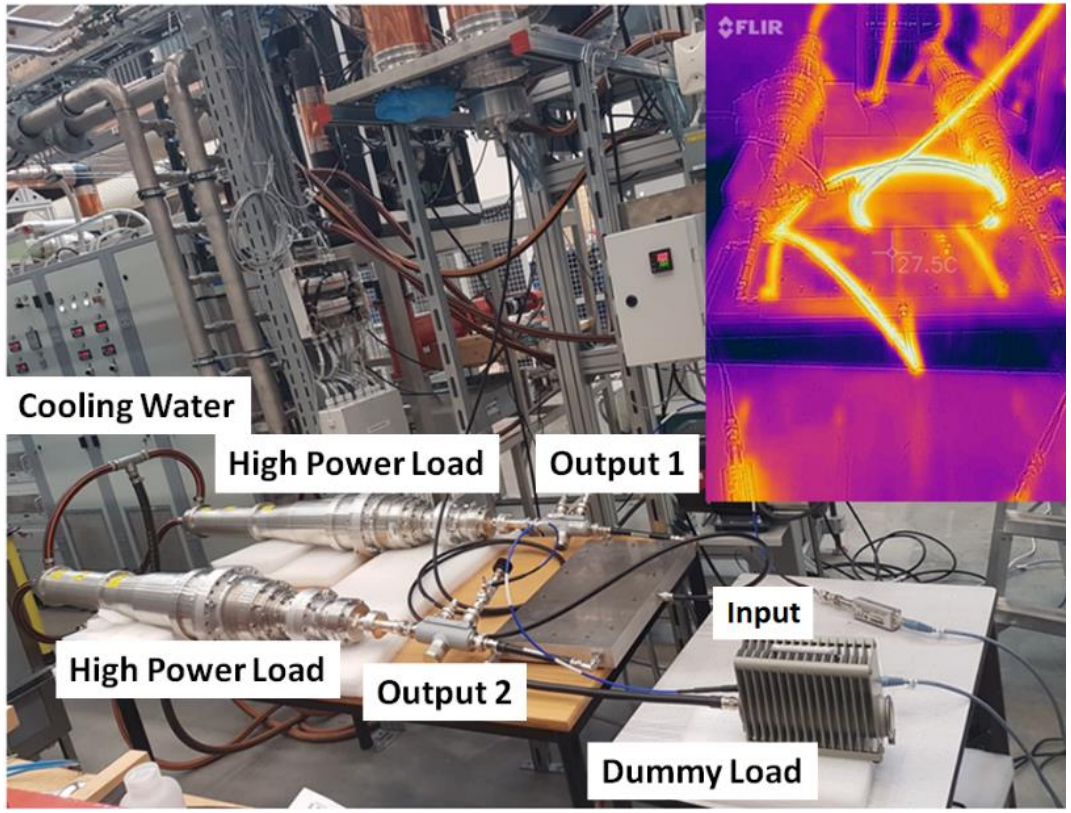
20 kW Gysel combiner at 352 MHz





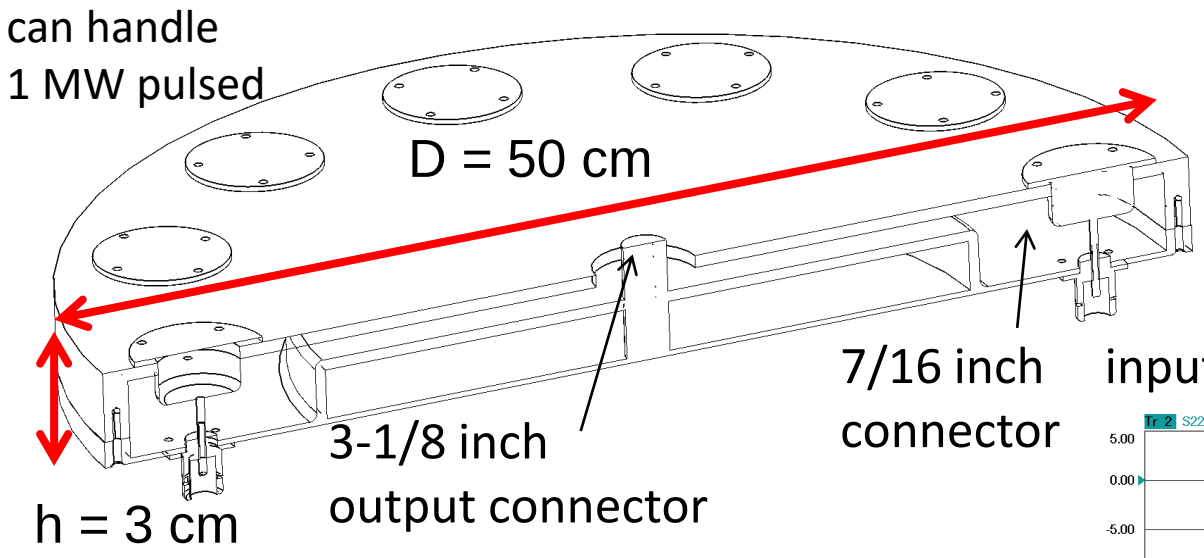


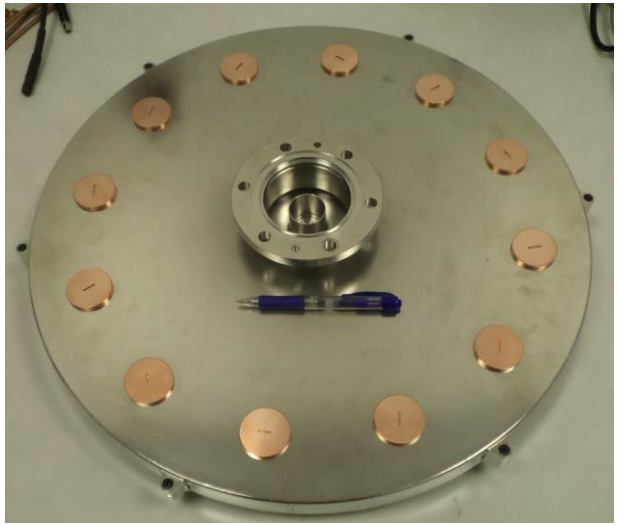
Tested up to 20 kW
IL 0.1 dB

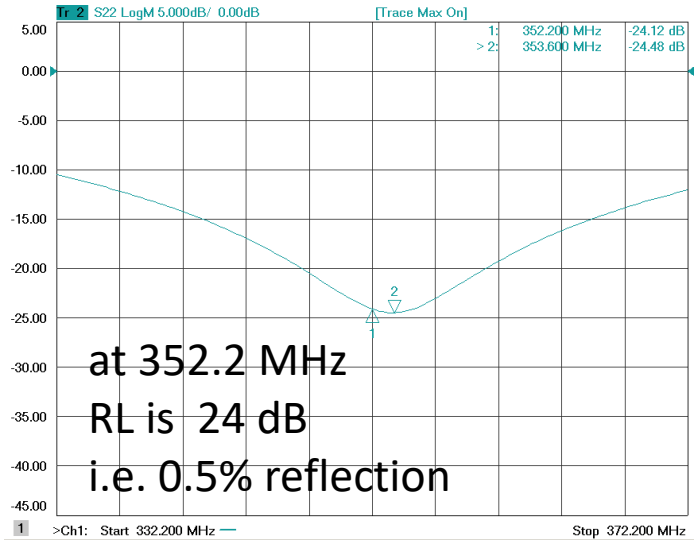


L. Hoang Duc et al., “A new high-power low-loss air-dielectric stripline Gysel divider/combiner for particle accelerator applications at 352 MHz,” 2017, Journal of Engineering.

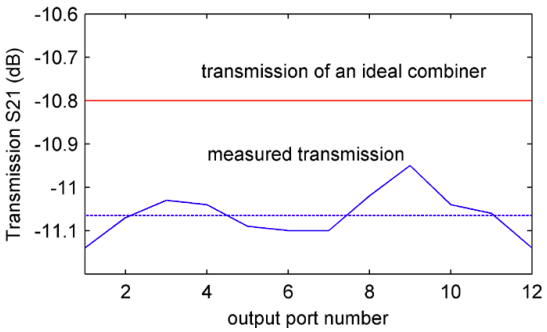
100 kW non-resonant power combiner with door-knob couplers at 352 MHz







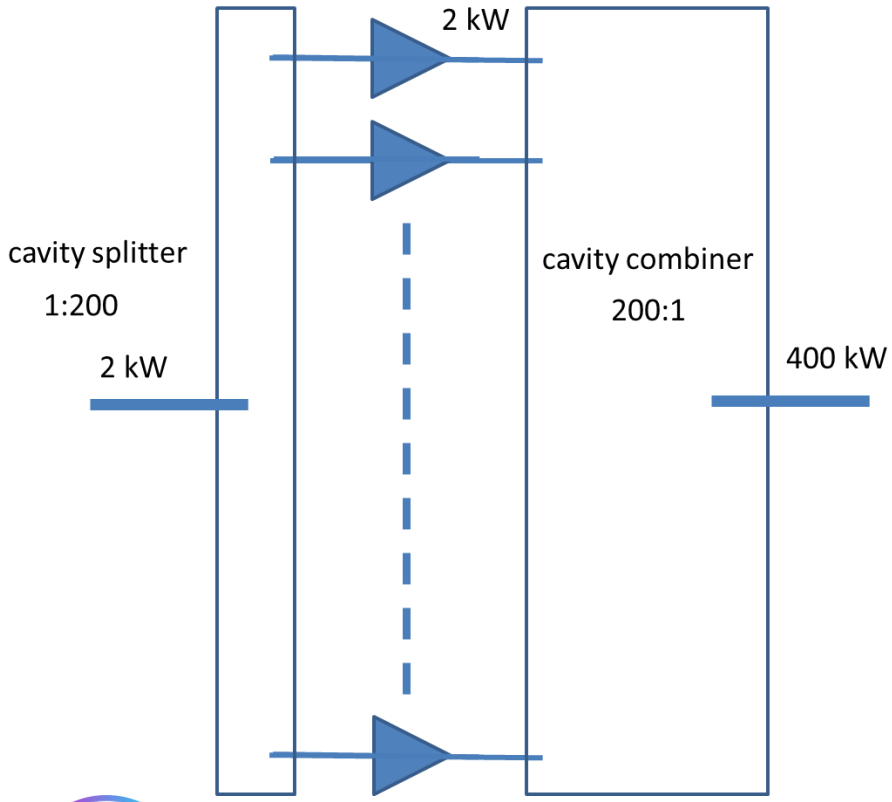
at 352.2 MHz
RL is 24 dB
i.e. 0.5% reflection

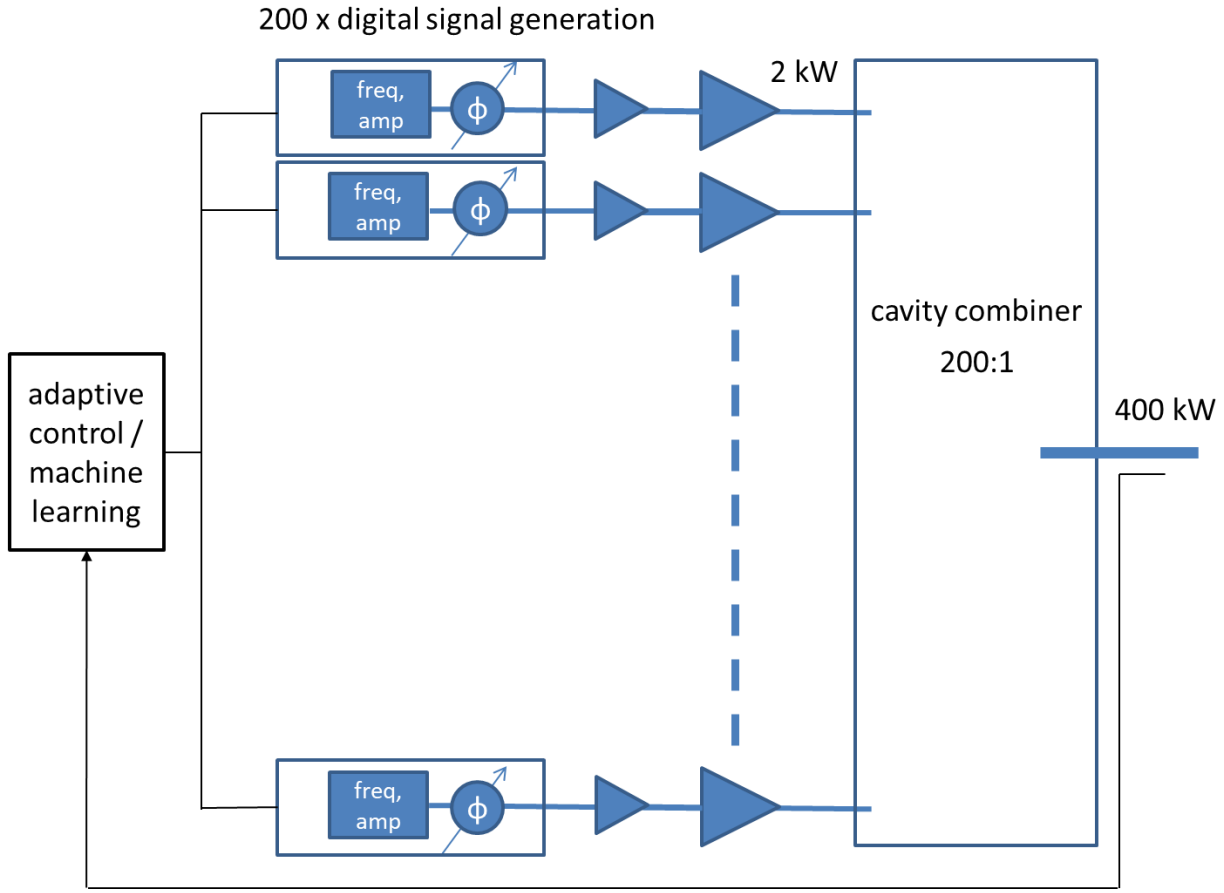


at 352.2 MHz
IL is 0.3 dB i.e. 6% losses

V. A. Goryashko, D. Dancila, A. Rydberg, R. Yogi & R. Ruber (2014): A megawatt class compact power combiner for solid-state amplifiers, Journal of Electromagnetic Waves and Applications.

Leading to novel architectures for high power amplifiers (several hundreds kW output power)

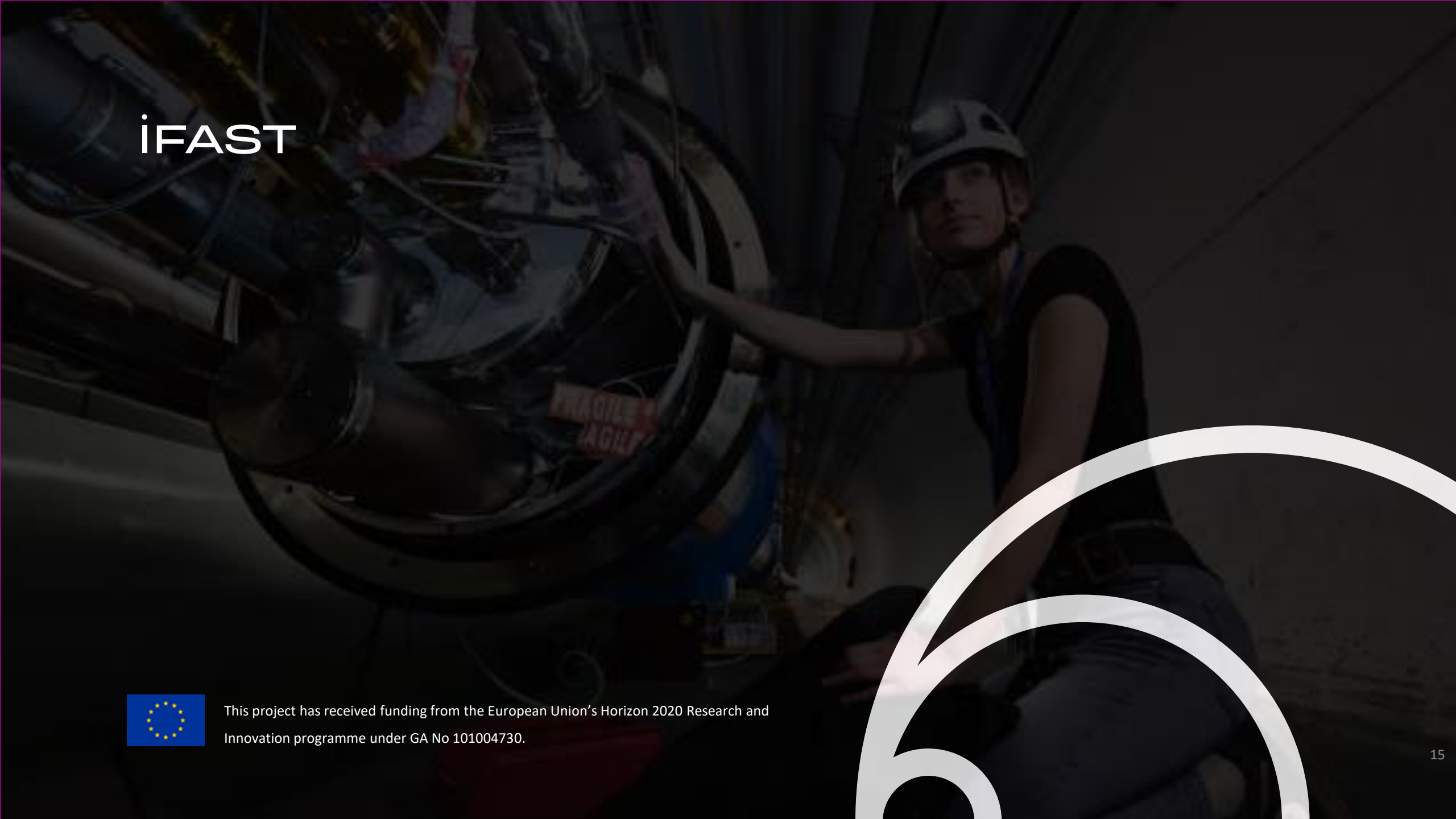




Contribution to Task 13.2: Developing and promoting services to industry in AMICI Technological Facilities (TFs)

- Setting up a discussion with European research institutes and Industry, where solid state power amplifiers technology is being currently developed.
- Create a central contact point and pushing for adopting well-defined procedures, regulations, cost evaluation schemes, quality standards, etc.
- Ensure the availability of the latest developments in the Task 13.3 – GaN amplifers, as AMICI TP, for internal and external partners.
- Develop and promote services to industry, research laboratories and other technology stakeholders.

Thanks and questions



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