Elettra Sincrotrone Trieste

Elettra
Sincrotrone
Trieste

News from Elettra

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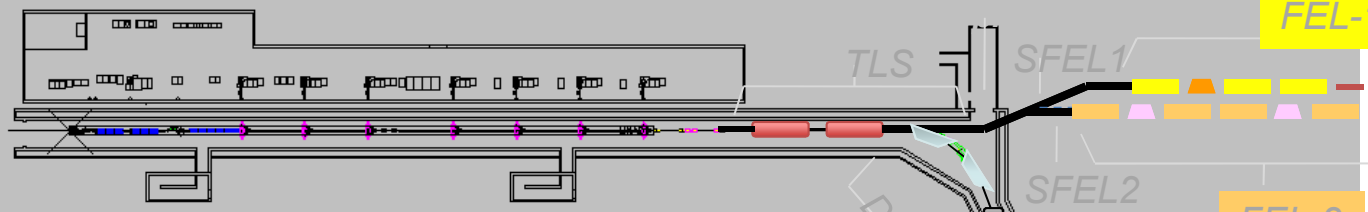
Elettra Sincrotrone Trieste

Content

- ✓ Elettra RF Plants statistics
- ✓ New Installations
- ✓ Conclusion

Accelerators of Elettra

Elettra Sincrotrone Trieste

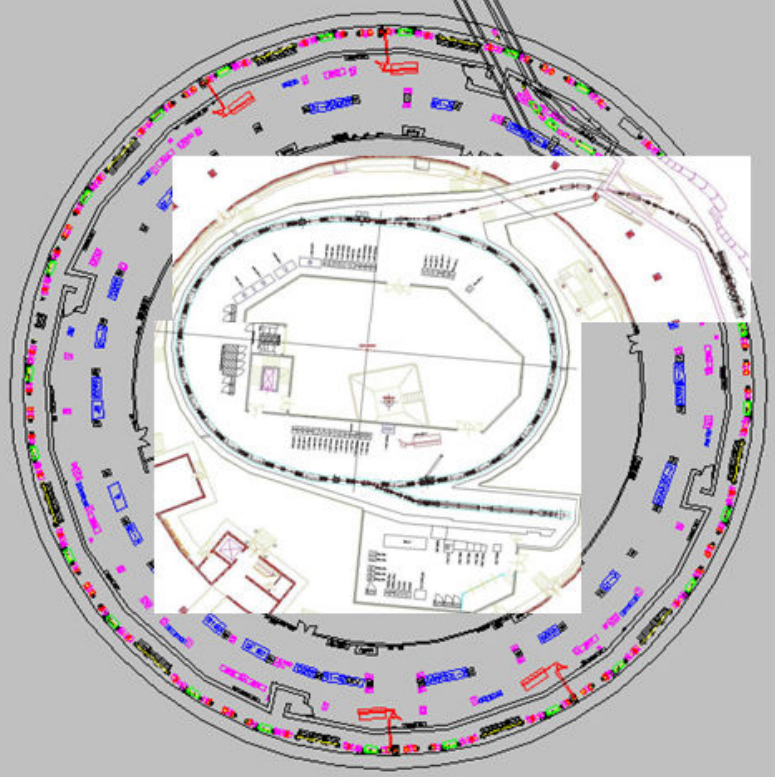


1994 – 2007:

Elettra Storage Ring came into operation in 1994, being the first third generation light source for soft-X rays in Europe.

Initially max. energy 2 GeV, currently operating either at 2.0 GeV and 2.4 GeV

As injector used a linac (no full energy injection)



Since 2011:

4th Generation LS

Since 2008:

Full energy injector (linac + booster) at 2.0 & 2.4 GeV

Since 2010:

Regular TopUp operations during Users' beam time

Built WITHOUT affecting Elettra operations!

The Elettra RF Power Stations

Elettra Sincrotrone Trieste

Storage ring

4 RF stations

3 x 60 kW klystron plants

1x150 kW 2*I.O.T.s plant

Power dissipation @ Vacc [kW]	**122**
Power to the beam @ 2.0 GeV [kW]	**70**
Max Available Power [kW]	**315**

150 kW Power Station in operation since 2017

IOT tubes 80 kW each E2V D2130 (Thales 793 & 793-1 not reliable)

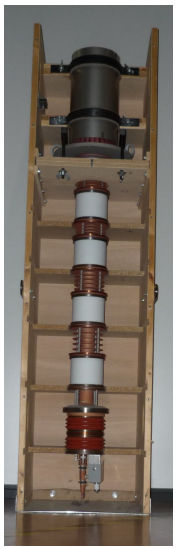
Till October 23rd

Booster

1 station

1 x 60 kW klystron plant

Power dissipation @ Vacc [kW]	**14**
Power to the beam @ 2.5 GeV [kW]	**1**
Max Available Power [kW]	**55**



60 kw Varian TVT transmitters in operation since the beginning of Elettra

Klystron E2V k3672 B.C.D. discontinued in 2012

RF Power Plants Data

Transmitter	Tx-A		Tx-B	
Heater time	53800		52700	
Tube	E2V D2130		E2V D2130	
Serial number	302 -1017		368 - 1208	
Installation date	2010 June		2012 June	
TX heater hours	60130		59090	
Year	operating hours	trip	operating hours	trip
2010	3700	7	---	---
2011	10700	4	---	---
2012	15500	3	3250	3
2013	20650	0	9650	1
2014	25580	0	15110	2
2015	31800	0	21500	0
2016	36900	0	25950	0
2017	43260	0	32330	0

Tube 302-1017: 40 kW and I _ grid = 25 mA

Tube 302-1208: 40 kW and I _ grid = 85 mA

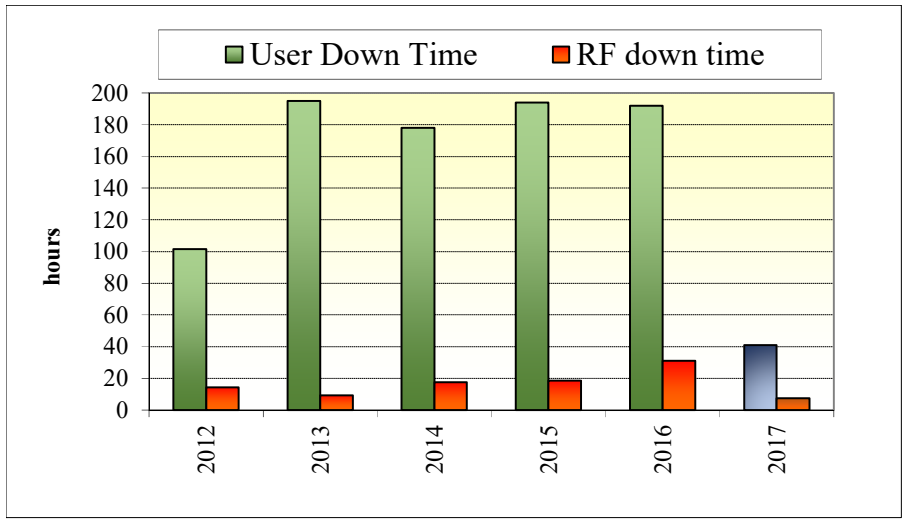
At Elettra : klystron average hours: 30000 (statistic over 17 klystrons)

RF station	klystron	SN	tube hours	Amplifier heater hours
Booster	K3672 BCD	1083-0351	**53100**	127000
RF #2	K3672 BCD	1184-0823	**47970**	140000
RF #3	YK1256	14105.265	**36120**	142000
RF #8	K3672 BCD	1184-0823	**48300**	141600

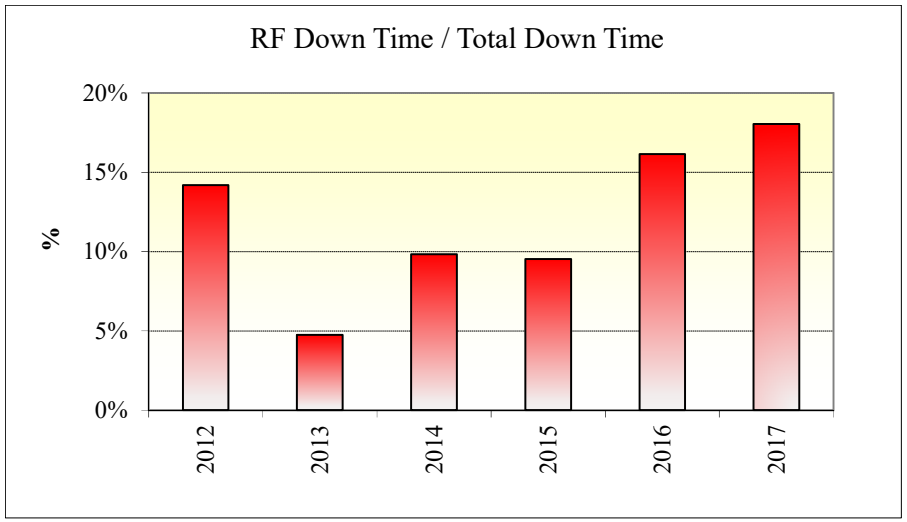
Year 2017: data taken up to October 20

RF Up-Time & Failure Statistics

- ✓ Statistic shown from 2012 (both IOTs from E2V – no more TH 9673 issues).
- ✓ Run 167 & 169 for Year 2017
- ✓ **RF plants reliability is worsening!**
- ✓ Note: **Any RF fault is FATAL: it means BEAM DUMP**

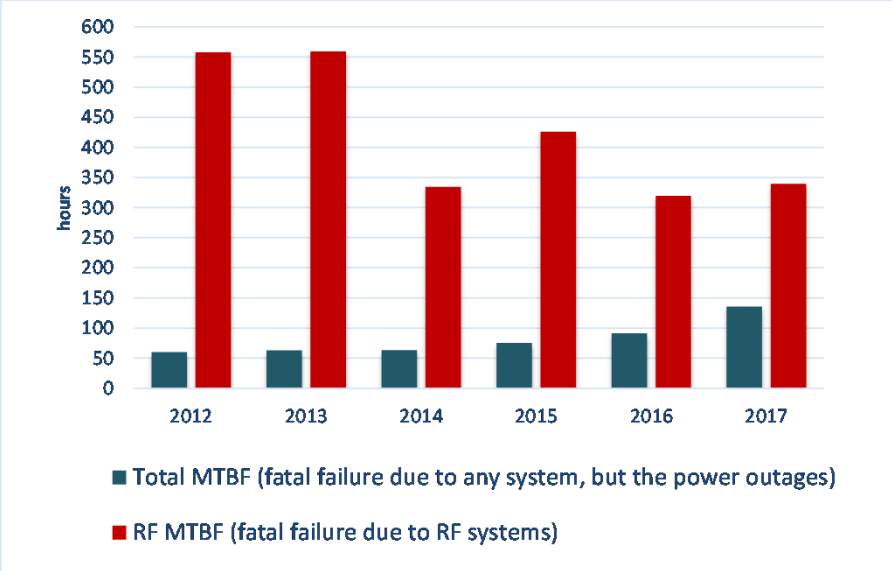


USER down time



TOTAL down time, including machine accelerator physic shifts

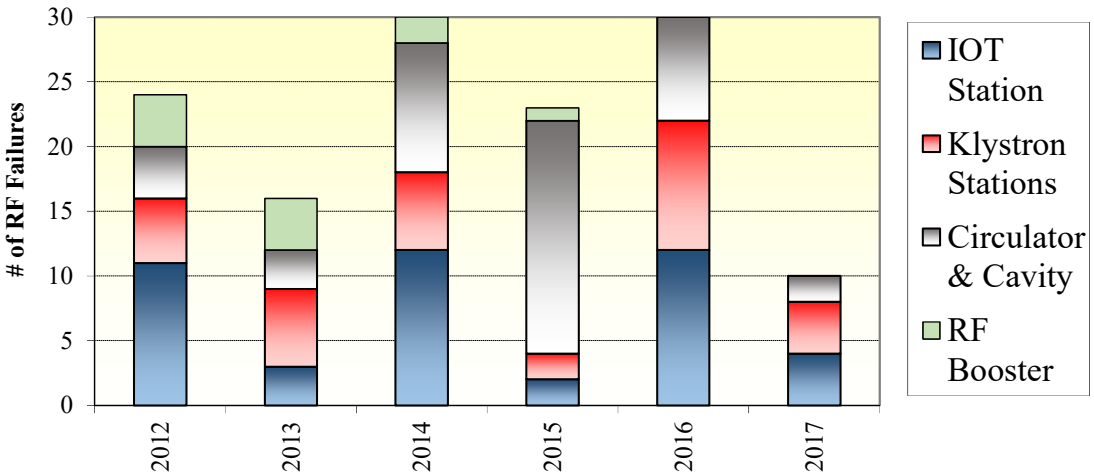
RF MTBF & Failures



- ✓ Data about the **M**ean **T**ime **B**etween **F**ailure refers to the scheduled user time and fatal failure (it means beam completely lost or its intensity drops below 50%).
- ✓ In 2016 and 2017 (run 167 and 169) RF MTBF reduced by 40% from the best performance (560 h).
- ✓ Total Elettra MTBF is improving.

RF failures sorted by hardware and kind:

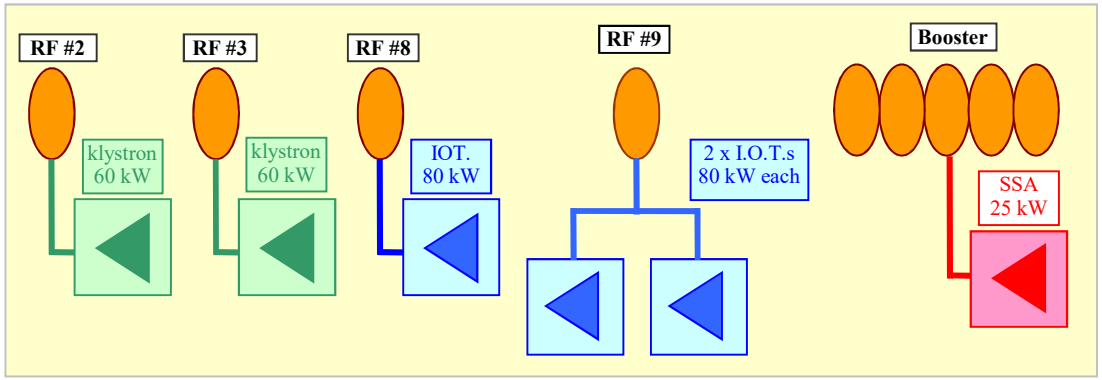
- ✓ Booster issues ⇨ **SOLVED**
- ✓ Cavity issues ⇨ **SOLVED**
  but the circulator arc.
- ✓ IOT & Klystron stations
  ALWAYS PRESENT



Running Project

March 2013: Project P2013096 "RF Power for Elettra" STARTED

Project goal was to replace two RF power stations with another IOT station for the Storage Ring and a smaller power size RF statin for the Booster.



The project was organized in three work packages:

1. "**IOT installation**" package: purchase a 80 KW IOT based transmitter, the very same already installed, to share spare parts and servicing know how and reduce costs (that time Solid State was more expensive than tubes).
2. "**SSA validation**" package: some developments were forecast for R&D of the high RF power combination.
3. "**SSA installation**" package. Purchase and install 25 kW SSA for the Booster. The better efficiency of this machine will allow to electricity savings around 80,000 Euro /year (1 kWh =0.18 Euro).

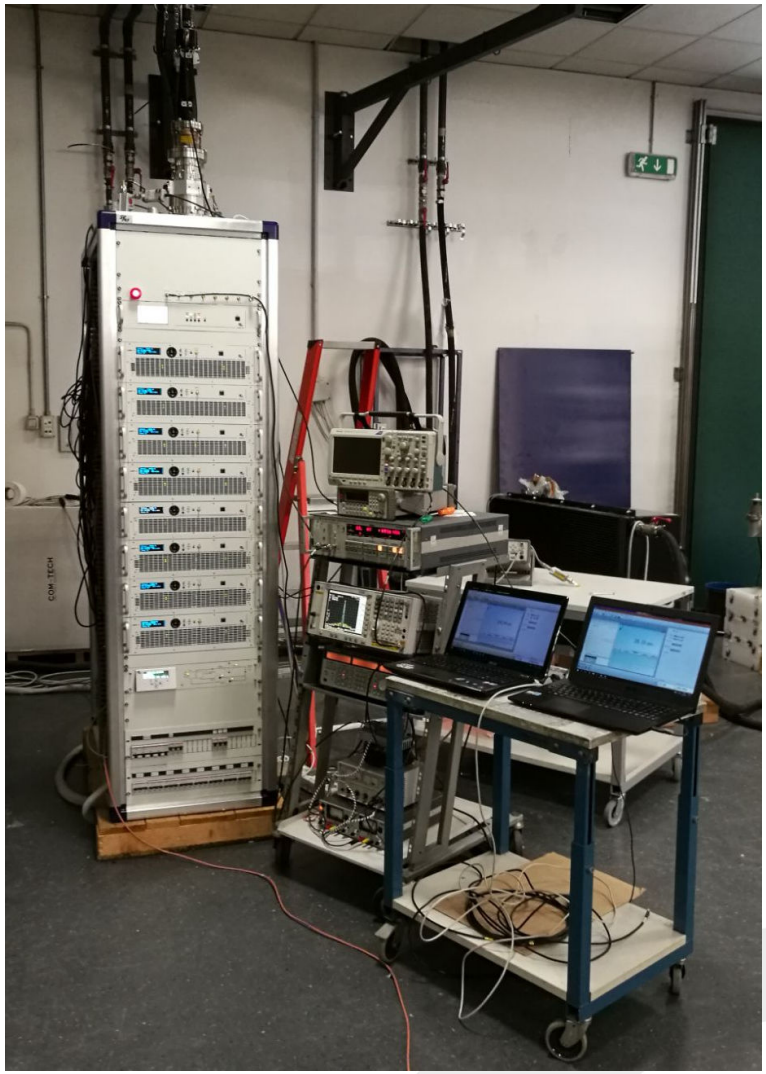
Running Project

October 2017: Project P2013096 "RF Power for Elettra 2" STATUS

"IOT installation" package: ABORTED
Technical Specifications Ready & Tender Procedure ready to start but the financial troubles (bankrupt) of the identified manufacturer suggests us to postpone the Tender procedure. **Now the tested reliability of the IOT station and the maturity of the Solid State Amplifier design are strong deterrent from resuming it.**

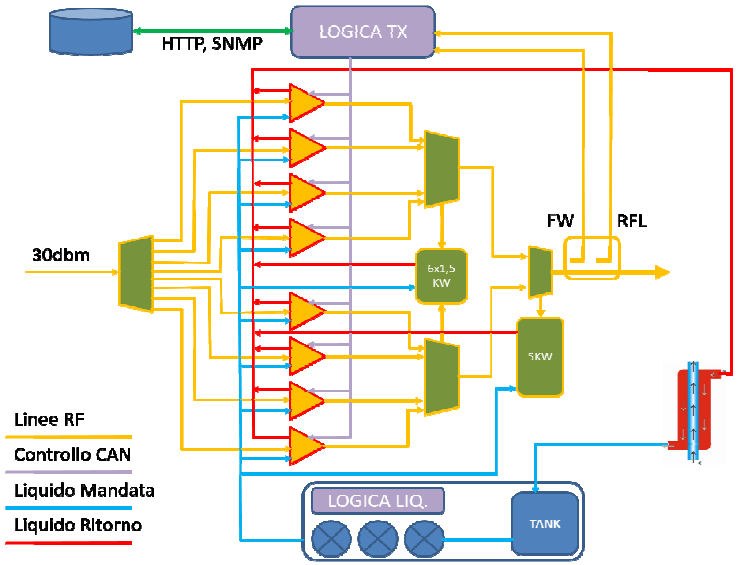
"SSA validation" package: ABORTED
New project – unexpected - arose (commercial contract Indus II and SESAME , ESS In Kind collaboration) so that there was no available man power to go on. It could be resumed.

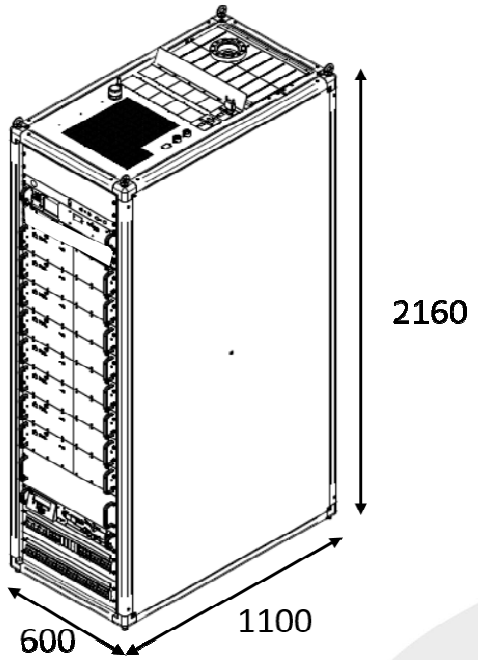
"SSA installation" package: COMPLETED
(October 23rd) a new 18 kW SOLID STATE AMPLIFIER has been installed in Booster Service Area.



18 kW Solid State Amplifier

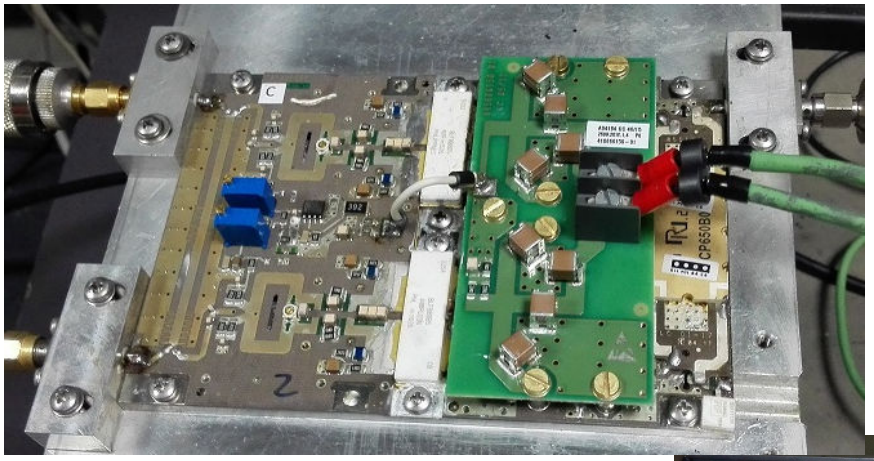
- 18 kW power range was set up on the basis of the “finally chosen” Booster operating energy (14 kW RF peak power @ 2.4 GeV . Some studies have been performed in the past to go beyond this energy value), energy redundancy and machine compactness (single rack).
- Specified as turn-key system, installation included. Specified to operate in CW to understand the Solid State possibilities and limits for any future implementation in the storage ring.
- The Contract was awarded to SYES (Italian company) among five bidders. The proposed machine is made of 8 RF modules – 2.4 kW each , combined together in a single rack including the cooling system.



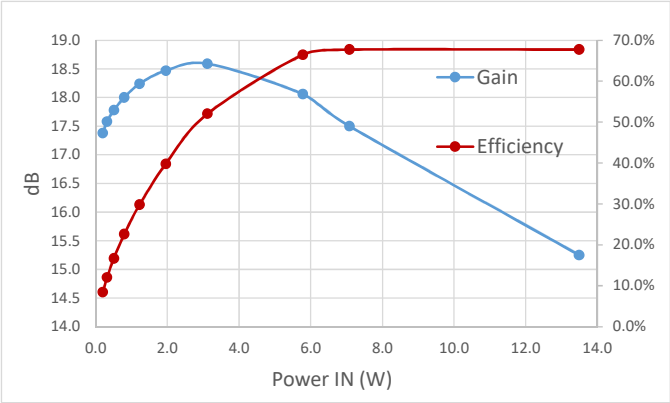


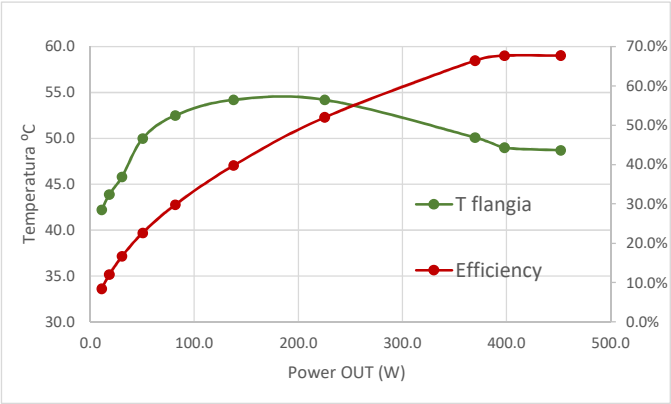
18 kW SSA: RF pallet

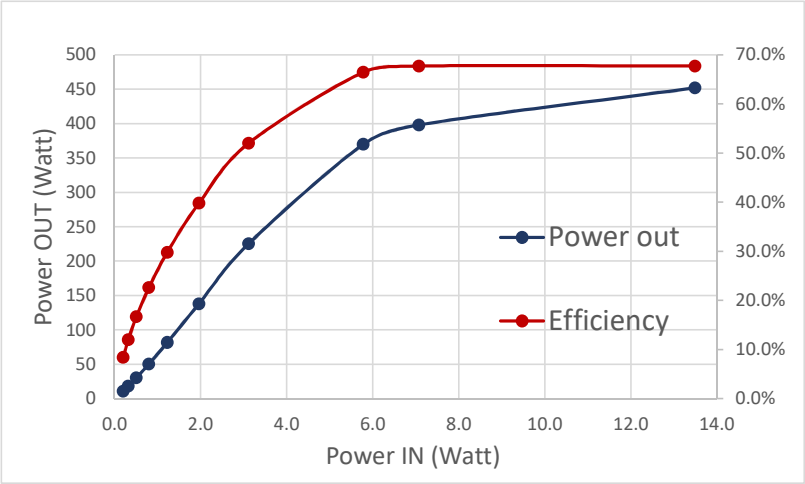
- The most relevant part of the SSA is the 400 W pallet. It is realized with two BLF888BS transistors (Ampleon).
- The RF pallet is developed and build by SYES for broadcast application but modified with the RCP650B03N LTCC Hybrid Coupler.



RF pallet during tests: RF and thermal measurements

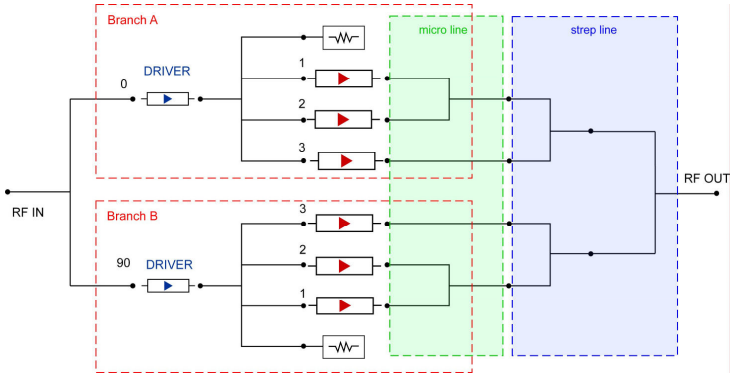


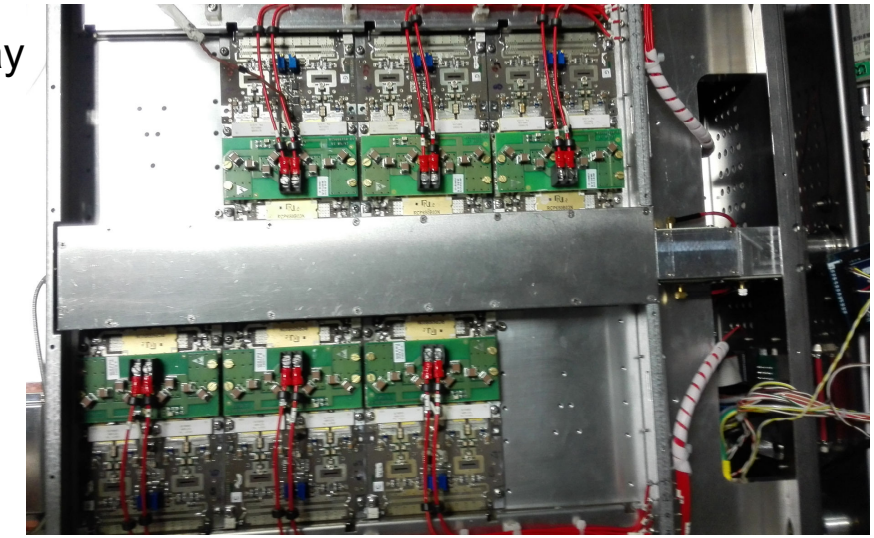


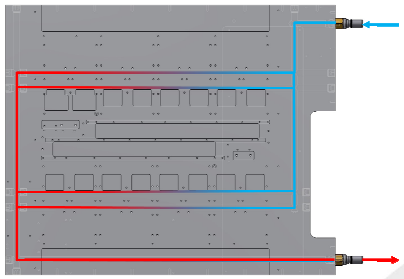


18 kW SSA: 2.4 kW module

- Eight equivalent “hot-swop” modules , nominal power 2.4 kW, are installed
- Each module hosts 2 drivers + 6 RF pallets.
- Each module has its own Power Supply (three GE CP2725AC48TEZ-FB, PS redundancy 50%)
- Each module is water cooled
- Each module hosts a microprocessor & local display



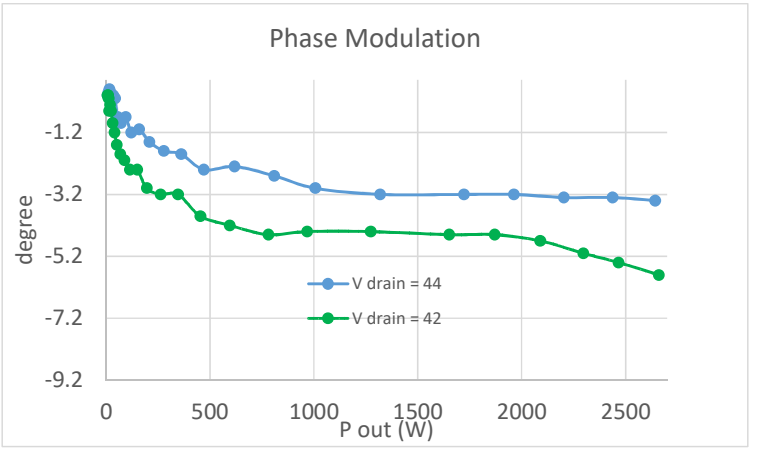


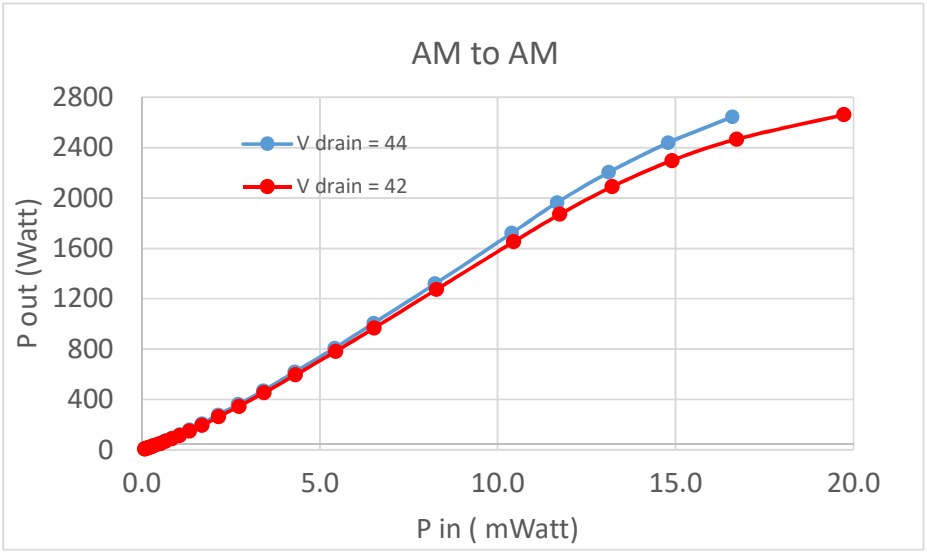


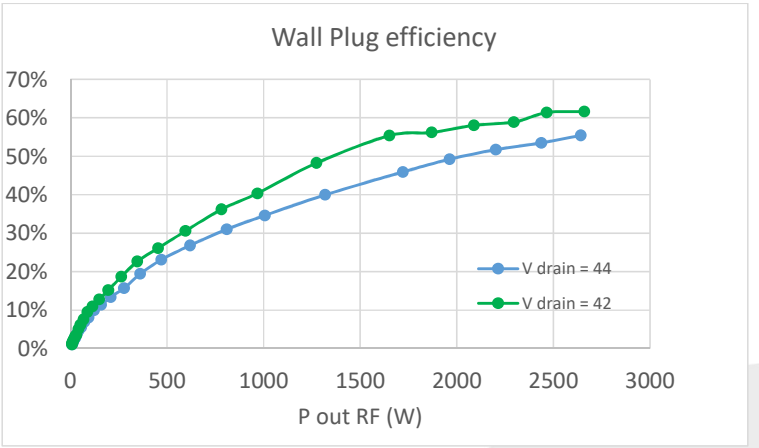
18 kW SSA: 2.4 kW module

The first module has been measured to check for the best parameter's set versus performances

V_drain (V)	P_out (Watt)	Gain (dB)	Δ ϕ	η– Wall-Plug
44	2650	52.0	3.4º	56%
44	2300	52.2	3.3º	54%
44	1200	52.0	3.1º	37%
42	2660	51.3	5.8º	61%
42	2300	51.9	5.1º	58%
42	1200	51.8	4.4º	40%

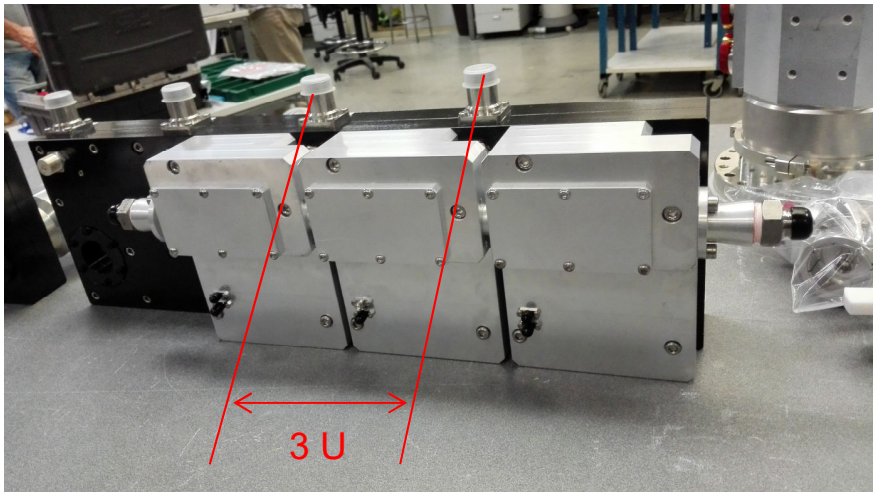






“High Power” Combination

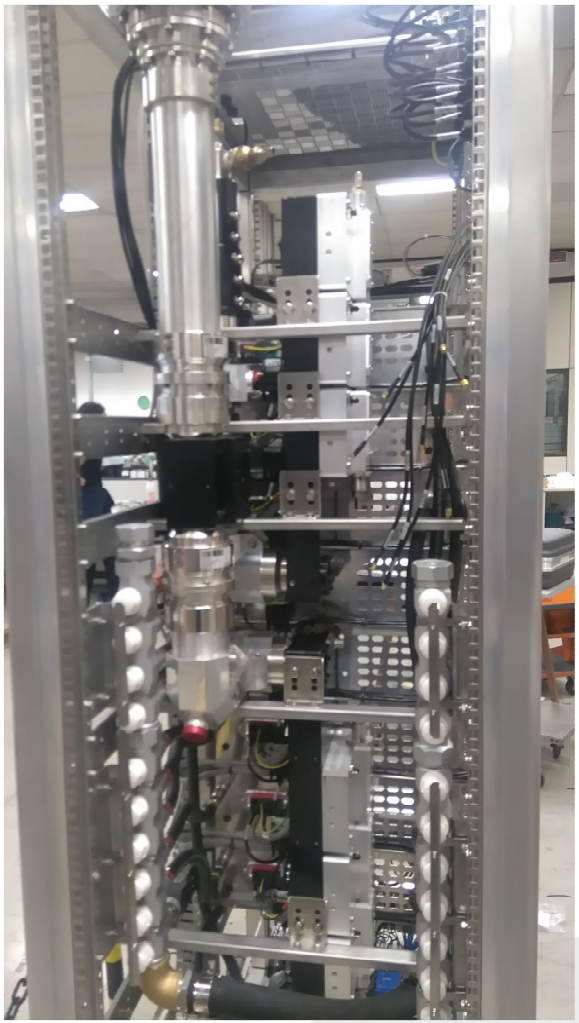
kW RF power range combination performed in two steps with no flexible cables but connected directly to the module’s unit with off the shelf COMM-TECH devices.



4-in -1 hybrid combiner

COMM-TECH MH4P60C

4 in-ports 7/8“

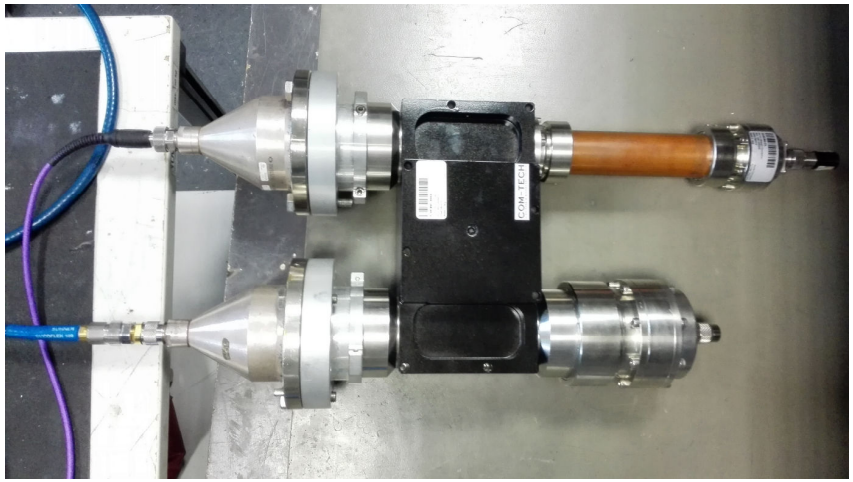


2-in-1 3 dB coupler

COMM-TECH

HC80C

3 ports 3 -1/8“
1 port 1 - 5/8 “



“High Power” Combination

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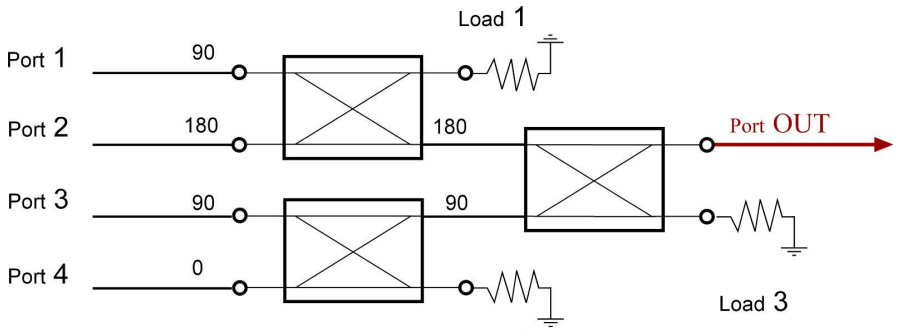
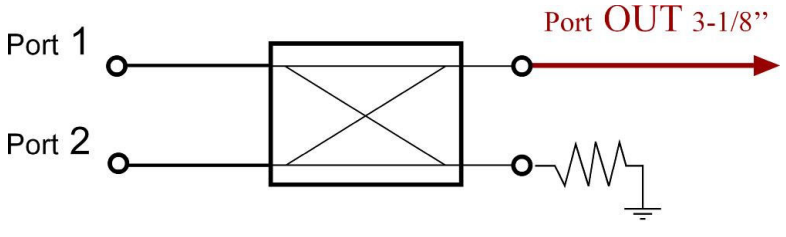
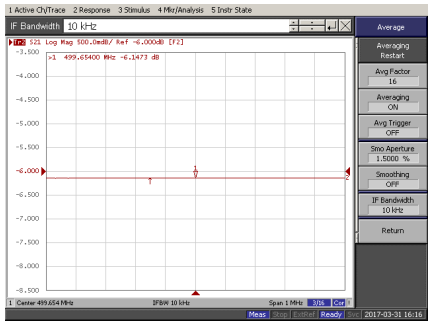
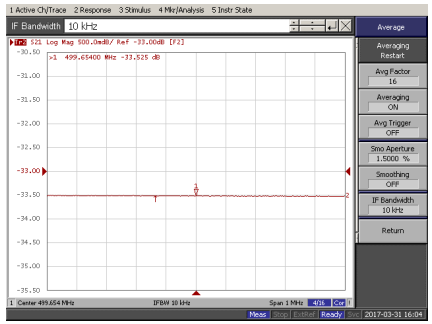
Combiner measured performances @ 500 MHz:

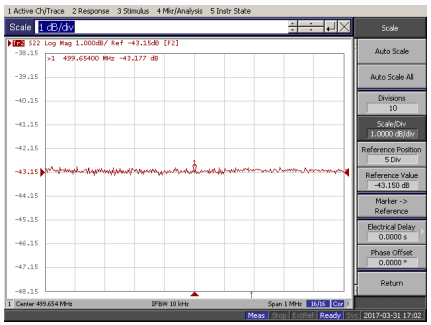


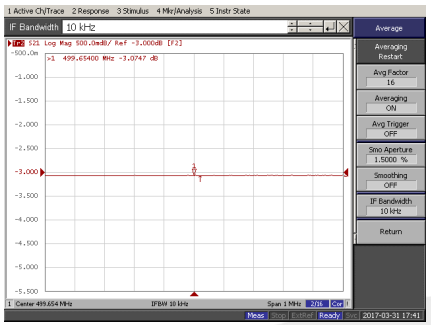


adattamento (dB)	Port 1	Port 2	Port OUT
	-43.2	-43.0	-37.3
transito (dB)	1 → out	2 → out	
	-3.01	-3.07	
isolamento (dB)	1 → 2		
	-34.9		







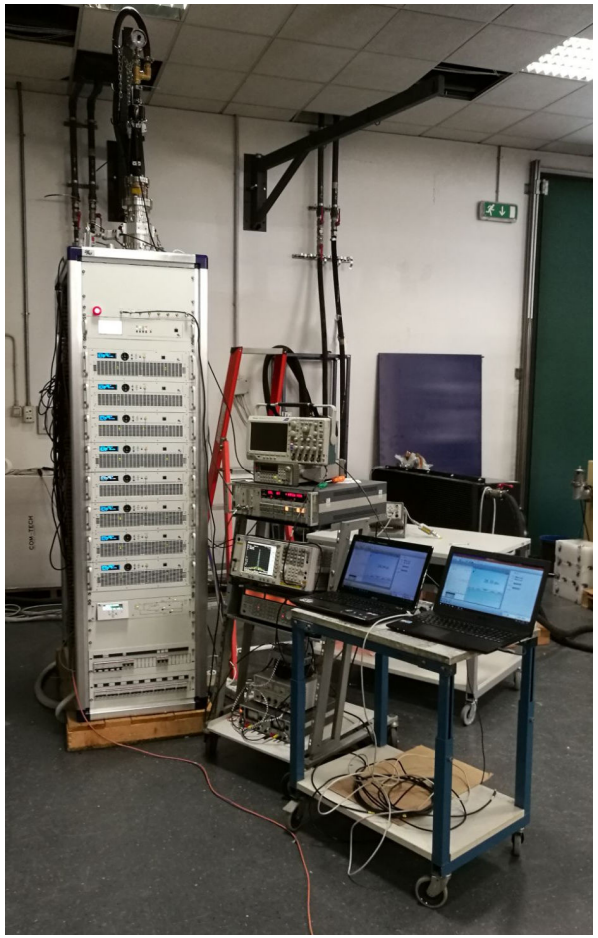


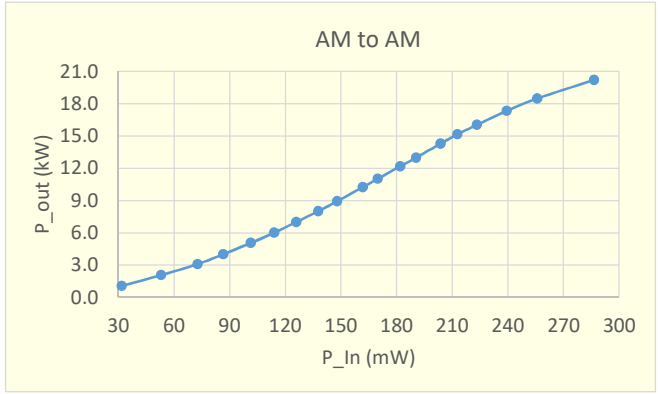
adattamento (dB)	Port 1	Port 2	Port 3	Port 4		
	-36.4	-36.6	-33.0	-40.2		
transito (dB)	1 → out	2 → out	3 → out	4 → out		
	-6.05	-6.15	6.06	-5.98		
adattamento (dB)	Port OUT	Load 1	Load 2	Load 3		
	-39.3	-32.4	-34.3	-35.3		
isolamento (dB)	1 → 2	1 → 3	1 → 4	2 → 3	2 → 4	3 → 4
	-35.1	-41.4	-41.4	-41.3	-41.4	-33.5

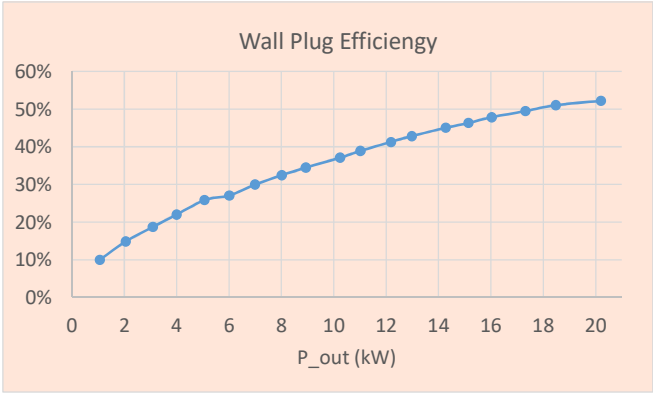
FAT

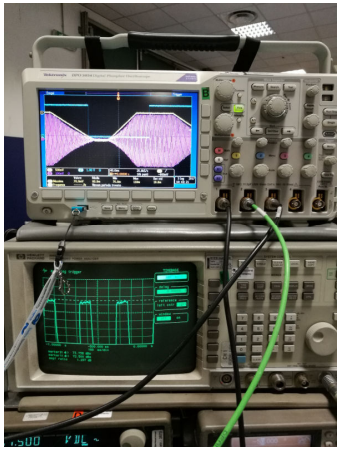
The complete transmitter has been characterized and tested according to the specifications (all requested characteristics and operating parameters OK).

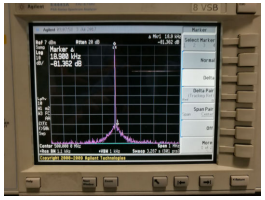
FAT Duration test of 24 hours at 18 kW, 500 MHz in CW passed with no failure.

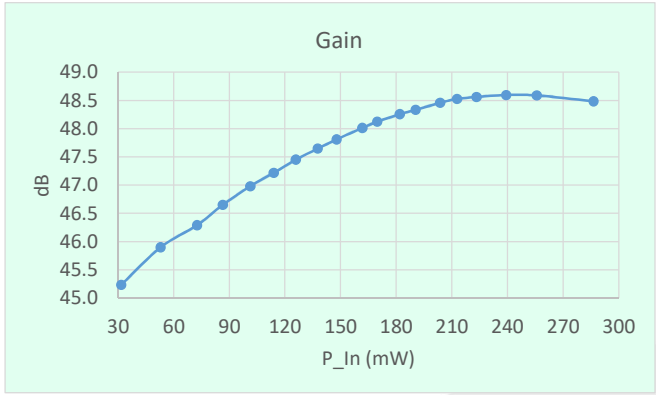












From 0 to 18 kW $\Delta\phi$ = 2.1º

Temperature max on the cold plate @ 18 kW = 56 ˚C
Stand by losses (pumps, logic and V_drain) = 5.3 kW

Elettra RF lab SAT

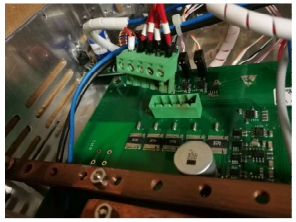
The machine has been tested also in the RF lab from July to October before the final installation:

- 2 weeks in CW at the nominal output power
- 2 weeks of operation in the Booster energy ramp mode
  repetition rate 2 Hz, output RF power trapezoidal shape;
- several hours at reduced output power with one module in OFF and one module's PS OFF;

Troubles during the RF lab test fixed by SYES:

- Hardware ones: a connector failure (poor contact, see snapshot).
- Firmware: one transistor's current monitor missed and the RF power calibration of one module missed.

Remote communication with the Elettra machine control system (underestimated the integration of the local control with the Elettra one). Solved after several iteration and firmware releases.



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Final Installation

In October 23 the transmitter was moved in installed in the final destination.

From October 27 it is operating on the booster cavity to capture and ramp the energy of the Elettra beam.

No problem experienced so far, but its operating time is still too short for any statistic data

Elettra Sincrotrone Trieste

Conclusion

- Unavoidable ageing of the klystron-based transmitters. Preventive maintenance does not help any longer. The failure is fixed when it happens and sometimes is being reparable with difficulty
- Ageing of the IOT-based transmitter after 10 years of operations. Extraordinary campaign for the HV converter has been carried on.
- 18 kW Solid State Amplifier installed and operating in the Booster. Its technical design follows the broadcast market with small modifications.
- New project is under preparation at Elettra for RF SSA for the storage ring (RF power budget ready for Elettra 2, $P_{nominal}$ > 75 kW). The performances and parameters of the Booster SSA will be used as a basis to specify the next machines.
- RF group is involved in the “In Kind Collaboration” with the European Spallation Source (ESS) for the 400 kW peak Power Stations @ 352 MHz.

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Trieste

Thank you!

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