

Status of the ELETTRA RF Plants



M. Bocciai, C. Pasotti, M. Rinaldi

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ELETTRA SYNCHROTRON RADIATION LIGHT SOURCE

Full Energy Injection

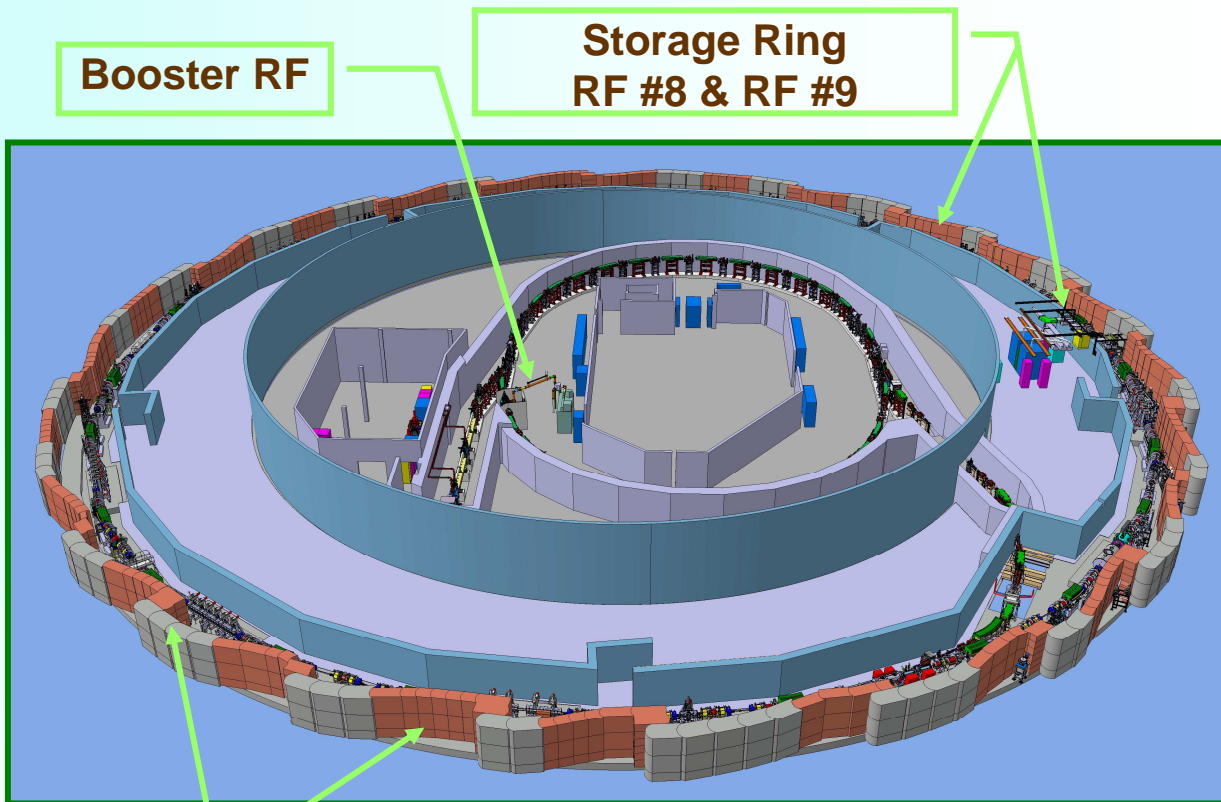
TOP UP Operation

Energy: 2.0 ÷ 2.4 GeV

Current: 300 ÷ 130 mA

User time > 5000 hrs/year

UpTIME goal > 95%



Storage Ring
RF #2 & RF #3



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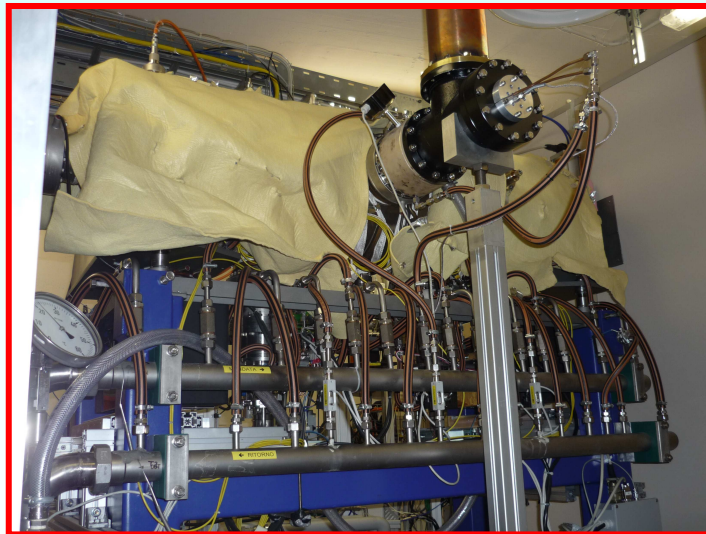


BOOSTER RF Plant

5 cells cavity (PETRA type)

Cavity voltage 40 to 600 kV; 3 Hz linear ramp

Klystron based Transmitter; 60 kW cw, heater's hours 84430



Troubles, but no user down time after two years of operation on LLRF. An EMC shield has been installed around the drive card of the stepper motor's.



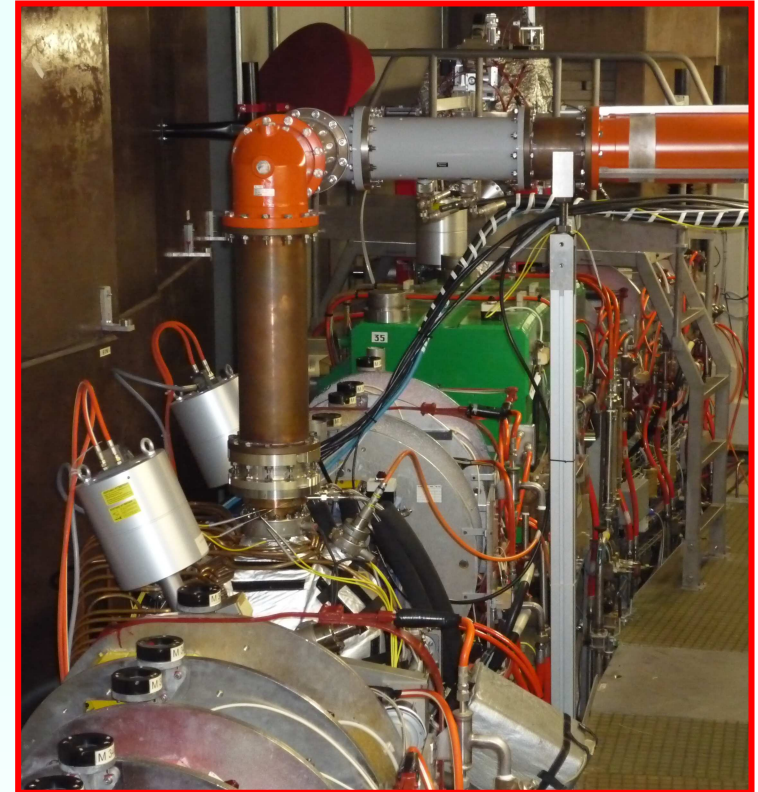
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STORAGE RING RF Plants

- ✓ 4 single cell ELETTRA cavities
- ✓ 3 Klystron based transmitters 60 kW
average heater's hours: 97740



Klystron's replacement in three transmitters from April 2009 to January 2010.



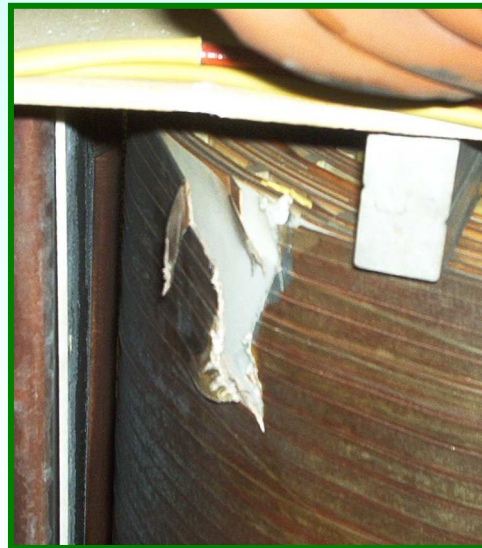
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Klystron based transmitter aging...

188 kVA 3phase transformer for this transmitter: one unit damaged during transportation from Storage ring to Booster in 2007... try to repair it !!!



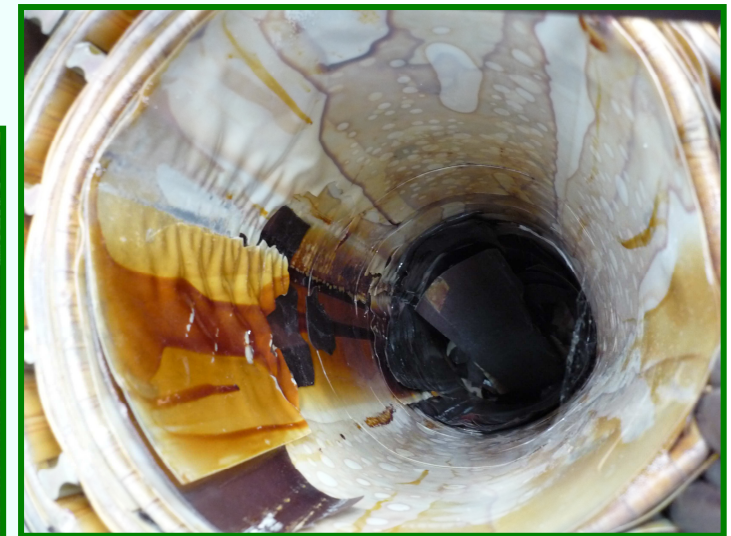
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Klystron based transmitter aging...

This unit was working fine until the transportation !!!
(transmitter ex RF #9 moved to booster)

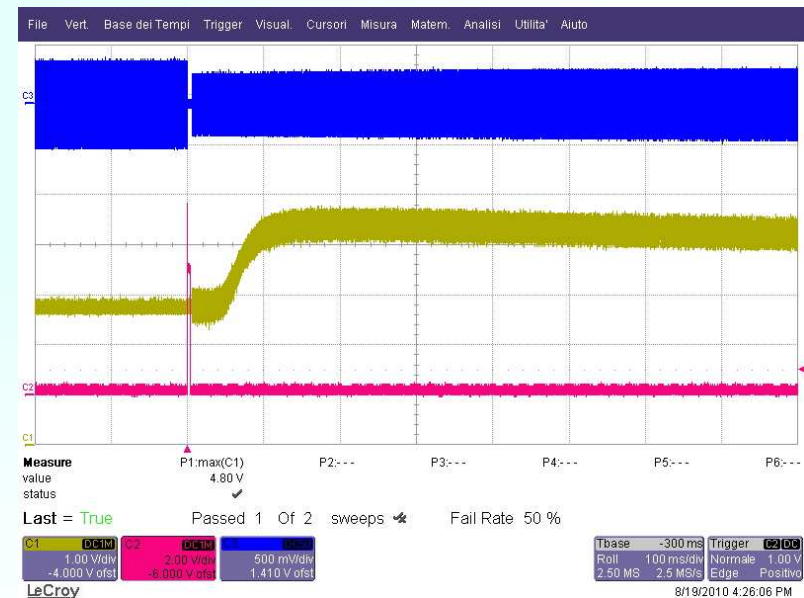
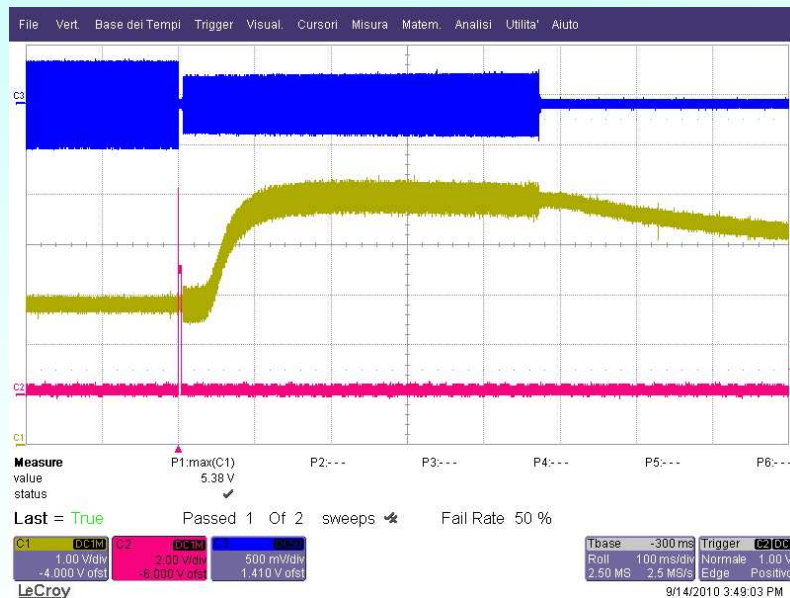


No way to repair it!



Beam dump and vacuum pressure bump of cavity RF#8

- ✓ Cavity and Input Power Coupler (IPC) installed in June 2009
- ✓ cavity +IPC conditioned (PM and AM) again and again, but the cavity trips (threshold $5 \cdot 10^{-7}$ mbar) in case of reflected power



IPC replacement foreseen next November 2010



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RF Plant #9



IOT- based transmitter:

- installed Jun-2006 (TH 793); 6 months commissioning; on cavity since Jan-2007
- two transmitters Tx-A and Tx-B of 80 kW/each; when combined: 150 kW RF



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Klystron and IOT tube statistics

RF plant	maker	type	s/n	start	stop	Hours (failed)	NOTE
#2	EEV	K3672 BCD	867-9904	4-Mar-99	24-Dec-09	66020	replacement
#3	Marconi	K3672BCD	0994-0121	15-Sep-03	15-Mar-09	32557	replacement
#8	E2V	K3672BCD	1038-0212	19-Oct-04	7-Jan-10	30898	replacement
Tx-B	Thales	TH793	574752	12-Dec-06	4-Jan-07	417	replacement
Tx-B	Thales	TH793	572382	18-Jan-07	3-Dec-07	4748	replacement
Tx-A	Thales	TH793	559442	01-Jun-06	01-Jul-08	11364	replacement
Tx-A	Thales	TH 793-1	617303	17-Oct-08	28-Feb-09	2378	replacement
Tx-A	Thales	TH 793-1	634010	21-Nov-09	13-Jan-10	240	CREDIT NOTE from Thales

RF plant	maker	type	s/n	start		Hours (in USE)	NOTE
booster	E2V	K3672 BCD	1083-0351	16-Aug-07		10516	NO FAULT
#2	E2V	K3672BCD	1177-0748	29-Dec-09		4820	NO FAULT
#3	E2V	K3672BCD	1105-0428	2-Apr-09		9693	NO FAULT
#8	E2V	K3672BCD	1184-0823	15-Jan-10		4681	NO FAULT
Tx-A	E2V	IOTD2130	302-1017	10-Jun-10		1628	5 stops
Tx-B	Thales	TH793	557132	1-Jun-06		14724	use only for SPARE- always faulty



IOT replacement "game"

Tx-A 18500 hours					
Type	s/n	Start	Stop	hours	Notes
TH793	559442	01-Jun-06	01-Jul-08	11364	max HV= 4.3 kV & low fil current. New reconditioning in Nov. 07 with no success
TH792 CD	005	08-Aug-10	16-Oct-08	1036	Thales loan. Good behaviour
TH 793-1	617303	17-Oct-08	17-Feb-09	2283	Found damaged grid wire. Installed along with the INPUT CIRCUIT TH 18793 LS s/n 37
TH 793-1	617303	17-Feb-09	28-Feb-09	+95	Tube TRIP - max HV =13 kV
TH 793-1	634010	21-Nov-09	25-Nov-09	74	Tube TRIP. HV only if cold
TH 793-1	634010	7-Jan-10	13-Jan-10	240	Installed after TED reconditioning (with TH 18793 s/n 37). NO success CREDIT NOTE from Thales
TH 790 SC	532893	21-Feb-06	11-Apr-10	309	Electrosys loan. Tube broken
TH792 CD	003	12-Apr-10	6-Jun-10	1566	Thales loan. Good behaviour
IOTD2130	302-1017	10-Jun-10	20-Sep-10	1628	in USE

Tx-B 22976 hours					
Type	s/n	Start	Stop	hours	Notes
TH793	557132	1-Jun-06	21-Dec-06	2463	Repeated HV Inhibit above 25 kW
TH793	574752	12-Dec-06	4-Jan-07	417	output ceramics discharge
TH790 SC	532893	5-Jan-07	18-Jan-07	18	Electrosys' loan
TH793	572382	18-Jan-07	3-Dec-07	4748	tube broken
TH793	557132	5-Dec-07	17-Feb-09	5809	Many trips. Dark spot on ceramic
TH792 CD	005	17-Feb-07	4-Jul-09	2406	Thales loan. Tube trip - max HV=19 kV
TH792 CD	003	4-Jul-09	10-Aug-09	663	Thales loan. Repeated HV inhibit at 25 kW. Try the reconditioning, no success. HV O.K., but repeated trips at 2-3 kW
TH793	557132	10-Aug-09	20-Sep-10	6452	Installed after Thales refurbishing - IN USE as spare



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IOT TH 793-1 operational experience

- ✓ **ELETTRA is a user oriented facility. Any installation shall fit the available shut-down time.**
- ✓ **The first installation of TH 793-1 in October 2008 (s/n 617303 - total hours 2378) was invalidated by a bad wire contact.**
- ✓ **The new tube (s/n 634010) successfully passed the Factory Acceptance Test of 24 hours at full power without trips.**
- ✓ **Before the shipment the tube was working for 300 hours at factory.**
- ✓ **The first installation of this tube (tuning & optimization) was done by personnel from Thales.**
- ✓ **Tube's monitor and check up of the whole system approved by manufacturer.**
- ✓ **In total, tube TH 793-1 was tested during week 46/2009 and 01/2010.**



TH 793-1 s/n 634010 - 1st Installation week 46/2009

date	time	Tx-A hours 15066. New TH 793-1 s/n 634010 & TH 18793LS s/n 37													Note	
		IF (A)	V HT (kV)	Iko (A)	V grid (V)	Igo (mA)	Driver (W)	Power (kW)	Gain (dB)	Ik (A)	Ig (mA)	Body (mA)	I foc (A)	Power downstream circulator		
10-Nov		24.6	35.0	0.15	-101	0.0										
installation		24.5	35.0		-101		58	10.0	22.4	1.10	0.0		18.4			
		24.5	35.0		-101		96	20.3	23.3	1.59	0.0		18.4			
		24.5	35.0		-101		130	30.3	23.7	1.91	0.0		18.4	28.5		
		24.5	35.0		-101		166	40.2	23.8	2.21	0.0		18.4	37.6		
		24.5	35.0		-101		201	50.2	24.0	2.48	0.0		18.4	45.3		
		24.5	35.0		-101		240	59.9	24.0	2.79	0.0		18.2	56.5	tuning output circuit	
		24.5	35.0		-101		283	70.0	23.9	3.10	0.0		18.2	66.0		
		24.5	35.3		-101		304	79.4	24.2	3.23	10.5		18.1	71.1	tube parameters optim.	
	16:30	24.6	35.1		-100		277	69.3	24.0	3.06	0.0		18.5	63.6	final set up	
11-Nov	9:00	24.5	35.1		-100		243	66.7	24.4	2.90	0.0		18.0		RUN all the night	
	15:00	24.5	35.1		-100		244	66.16	24.3	2.94	0.0	21	17.9	60.8	* NO faults last night	
	15:00	ALARM HISTORY = 22 HV INHIBIT, 1 ARC Cavity - just tests - INSTALLATION TIME 28 hours													Scope setting UP	
		Starting from 15:00, the IOT is running with this configuration (*) at constant level on dummy load (SMG 9.8 dBm)												RUN TIME	Start	
	18:12	HV INHIBIT													3h 12'	STOP
12-Nov	9:00	24.5	35.1	0.17	-100	0.0									Cold amplifier	
		24.5	35.1		-100		88	20.5	23.7	1.54	0.0	14	18.5			
		24.5	35.1		-100		159	41.3	24.1	2.54	0.0	16	18.5			
	9:35	24.5	35.1		-100		253	69.0	24.4	3.01	0.0	21	18.4		New start	
	9:48	HV INHIBIT													0h 10'	
	10:20	24.5	35.1	0.18		0.0										
		24.5	35.1	0.18	-100		251	68.5	24.4	2.96	0.0				New start	
13-Nov	4:57	HV INHIBIT													18h 37'	STOP
	9:00	24.5	35.1	0.16	-101	0.0									Cold amplifier	
		24.5	35.1		-101		255	69.9	24.4	3.01	0.0	21			Only test	
	10:00	Amplifier in STOP for the STORAGE RING CAVITY CONNECTION														
16-Nov	9:00	Impossible to set HV on the tube!														TUBE back to THALES
TX-A 15136 hours, ALARM HISTORY Δ =+3 HV Inhibit (true faults) RUN time 21 h 59 min 3 HV faults - INSTALLATION TIME 74 hours																



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IOT TH 793-1 operational experience

- ✓ **November 10 - 2009: day 1**
- ✓ **DAY 1: installation and tube parameter set up. Tube switched ON all the night @ 66 kW.**
- ✓ **DAY 2: final tube optimization. In the afternoon, 3:00 p.m. run time test @ 66 kW on the ferrite load started. First TRIP after 3 hours.**
- ✓ **DAY 3: Tube switched ON. 30 min to reach 70 kW and then the second TRIP. New start, third TRIP after 18 h 37 min.**
- ✓ **DAY 4: the tube was just switched on for test until the final RF output power of 70 kW was achieved. Total time 1 hour.**
- ✓ **DAY 5 : try to switch ON the HV. 3 attempts: after any trial the tube's HV threshold was decreasing!!!**



TH 793-1 s/n 634010 - 1st Installation

- ✓ The tube was running **ONLY** on the 50 Ω ferrite load, it has never powered the storage ring cavity.
- ✓ It was driven by a R&S SMG signal generator at a constant level.
- ✓ Three trips during this test. After the last it was re-started without problems
- ✓ Friday Nov. 13 switched OFF to allow the mechanical connection of the output wave guide to the storage ring's cavity.
- ✓ Monday Nov. 16 at the restart, it could not withstand the HV!
- ✓ HVPS, input circuit and cables "HV hold ON" checked with Spellman HVPS (current limited) and in the real operating condition.
- ✓ Tube was extracted from input circuit: no sign of discharge and the thermal paint was fine.



TH 793-1 s/n 634010 - 1st Installation

The tube itself (“cathode + grid” negative with respect to anode) had a discharge ~ 22 kV. (flash light was visible near the drift tube - anode area @ this HV level).

MAIN MALFUNCTION : Degradation of the grid to cathode insulation (measured impedance $\approx 300 \text{ k}\Omega$).

Tried a tube reconditioning at ELETTRA:

HV between the grid and cathode and HV between “grid +cathode” and anode (reversing the polarity from time to time) was applied.

Finally the grid to cathode **INSULATION** was restored.

The tube itself could withstand ~38 kV.

**BUT the tube was not holding the 35 kV
with heater switched ON !!!**



TH 793-1 s/n 634010 - 2nd Installation

- ✓ The tube was shipped to Thales for factory tests and re-conditioning.
- ✓ Jan. 7, 4:30 p.m., it was back to ELETTRA for the second installation.
- ✓ The tube was installed with the same tuning curve and optimized parameters as suggested by Thales.
- ✓ The tube was delivering RF power, 60 kW cw to the ferrite load at a constant drive for the first 3 days.
- ✓ DAY 1: tube setting up. At 5:30 p.m. the run time test started at 61 kW constant output power. First **TRIP** after 5 hours
- ✓ DAY 2: at 8:30 a.m. new run time test @ 20 kW. Second **TRIP** after 4 hours. At switching ON several **TRIPS** then once again run time test for 60 hours and 30 min. at 55 kW - constant level.



TH 793-1 s/n 634010 - 2nd Installation

✓ DAY 4: at 2:00 p.m. set the ELETTRA drive to the tube. Output power slowly increases from 30 to 55 kW (ELETTRA beam demand - but tube RF output power still on the ferrite load). One **TRIP** after 9 hours and 30 min.

✓ DAY 5: Two **TRIPS** at start up (NO RF power). One TRIP after 23 hours and 20 min

✓ DAY 6 : Several **TRIPS** at start up (NO RF power). It was not anymore possible to set the tube in HV.

**The tube was shipped back to Thales and
the credit note for the tube total amount was obtained.**



E2V IOT D2130 s/n 302-1017 - Installation

- ✓ The space available for the E2V input circuit could not be widened
- ✓ Several modifications to Electrosys Tx-A transmitter needed to host the E2V tube:
 - new output coax line
 - custom output coax elbow
 - lay-out of the cooling pipes re-arranged
 - new parameters for thresholds & interlocks
 - “knob” to raise manually the HV of the tube at the first start up (min. 22 kV)



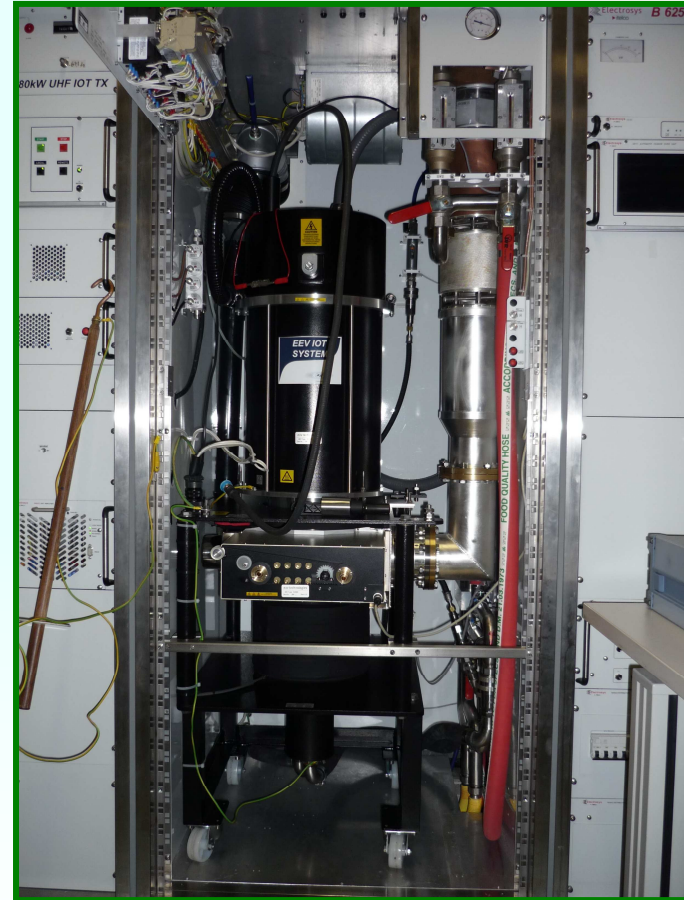
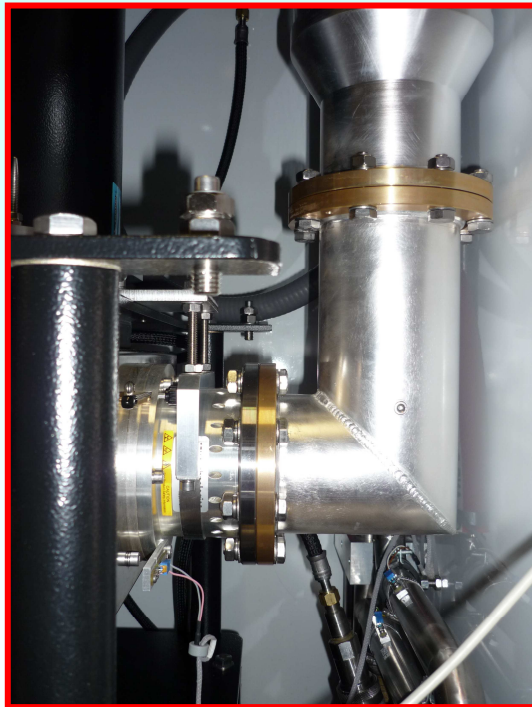
E2V IOT D2130 s/n 302-1017 - Installation

- ✓ Jun 7 the transmitter retrofit started
- ✓ Jun 10, 03:30 p.m. the tube was delivered at Elettra
- ✓ Jun 17 Elettra shut down last day
- ✓ No time to repeat the 24 hour FAT of the tube (1st trial failed).
- ✓ Jun 18 the E2V tube was feeding the Elettra cavity



E2V IOT D2130 s/n 302-1017 - Installation

The E2V input circuit FITs exactly the cabinet (5 mm left)!



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E2V IOT D2130 s/n 302-1017 - Installation

✓ 1st start up:

Warm UP (heater ON): **30 min.**

HV raise (22 ->36 kV) : **2 hours**

✓ Tube's tuning and parameters performed according to the E2V procedure

✓ Max power 70 kW (our choice)

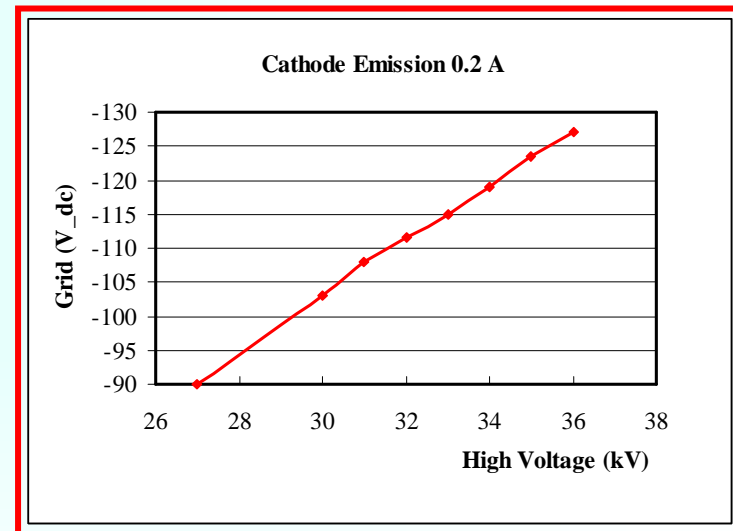
✓ @ 50 kW output power

efficiency = 57.9%

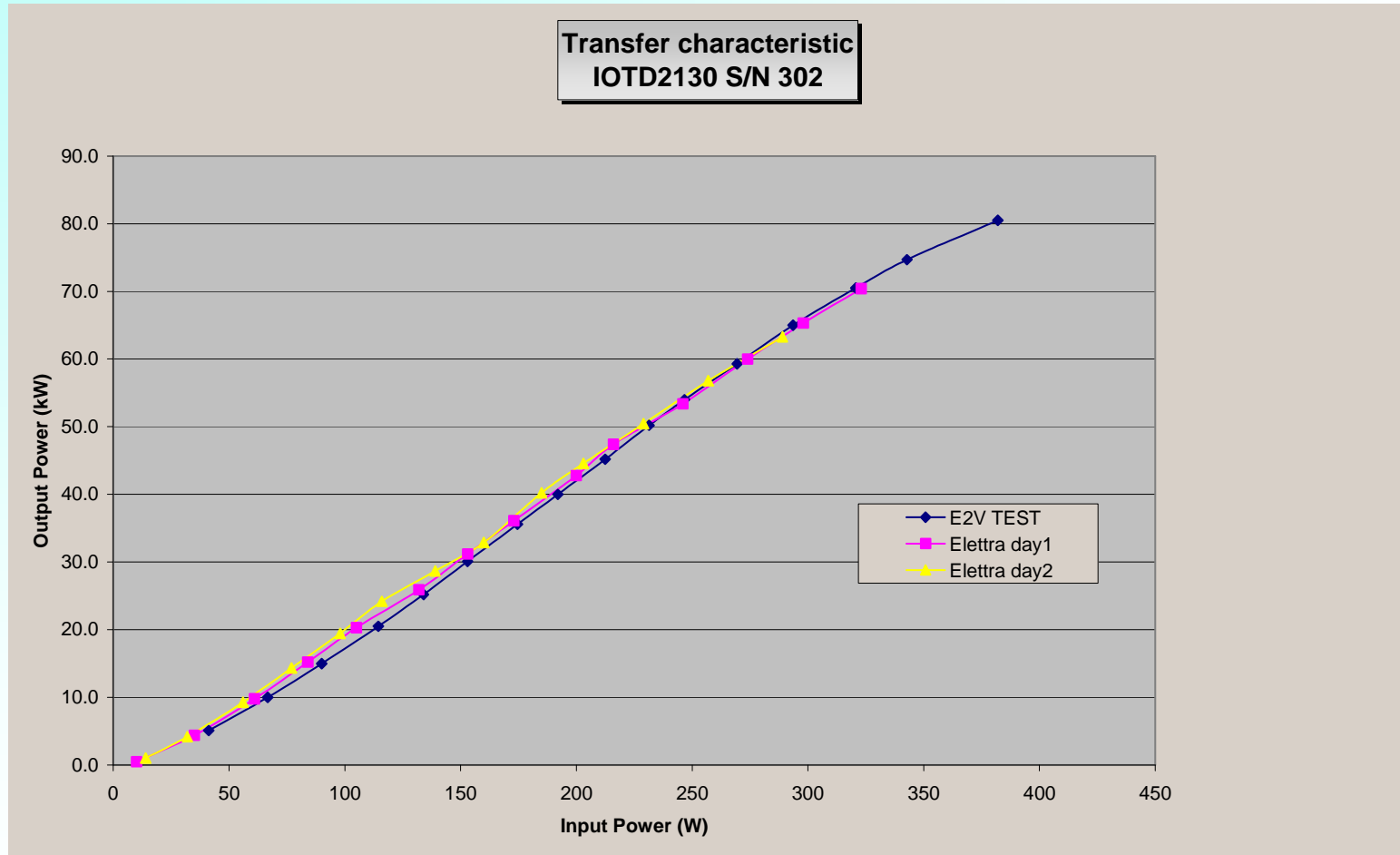
gain = 23.4 dB

input circuit RL = 15.7 dB

BW = 3.8 MHz



E2V IOT D2130 s/n 302-1017 - Installation



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Conclusion

- ✓ Thales TH 973-1 did not solve the reliability demand.
- ✓ E2V IOT D2130 has been just installed. Not enough hours to definitively weigh its performances.
- ✓ The two RF#9 transmitters are settled for TWO DIFFERENT TUBES. This is really “unpleasant”. ASAP a UNIQUE standard shall be implemented.
- ✓ Ageing on the klystron based transmitter: new solutions are being investigated.

Thanks to the DESY (Michael) for info about the booster plunger, and, mainly, to DIAMOND (Morten and Peter) for their support about the new tube installation.

