Elettra Sincrotrone Trieste

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Trieste

Present Status of the Elettra RF System

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Elettra Sincrotrone Trieste

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- ✓ The Elettra Facility & the RF system
- ✓ Elettra UP-TIME and MTBF
- ✓ RF Fault Survey
- ✓ Beam Dump Monitor and RF signals
- ✓ RF Power Source Statistic
- ✓ Cavity replacement
- ✓ Conclusion

The Elettra facility

- ✓ 3rd generation light source **2.0** - **2.4 GeV**

  Full Energy Injector (2008):

  100 MeV conventional LINAC +2.5 MeV Booster

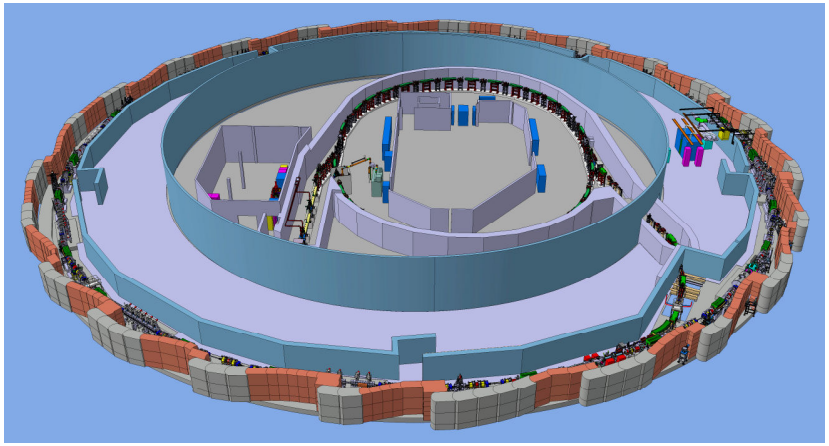
  Storage ring (1994) double bend achromat

  Ring circumference 259.2 m
  Emittance 7 nm-rad & 1% coupling
  Beam Dimension @ IDs 250/14 μm
  Beam Length nat.=25 ps, with 3HC > 100 ps

- ✓ **310 mA** (2.0 GeV) and **160 mA** (2.4 GeV)

  Standard filling 410/432 bunch train
  Hybrid filing 410 bunch train + single bunch

- ✓ **TOP-UP** , ΔI =1 mA, time span= 5 ÷ 20 min
- ✓ 5000 hours/year scheduled for the user
- ✓ 27 beam lines + 2 under construction
  - 22 ID segments + **1 SCW 3.5 T (2015)**
  - 6 bending magnet sources points
- ✓ **goal uptime > 95%**



The RF System

Nominal Frequency 499.654 MHz

Storage ring ΔE/turn ≈ 300 keV

Storage ring

4 RF stations

NC single cell copper cavity
3x 60 kW klystron plants
1x150 kW 2*I.O.T.s plant

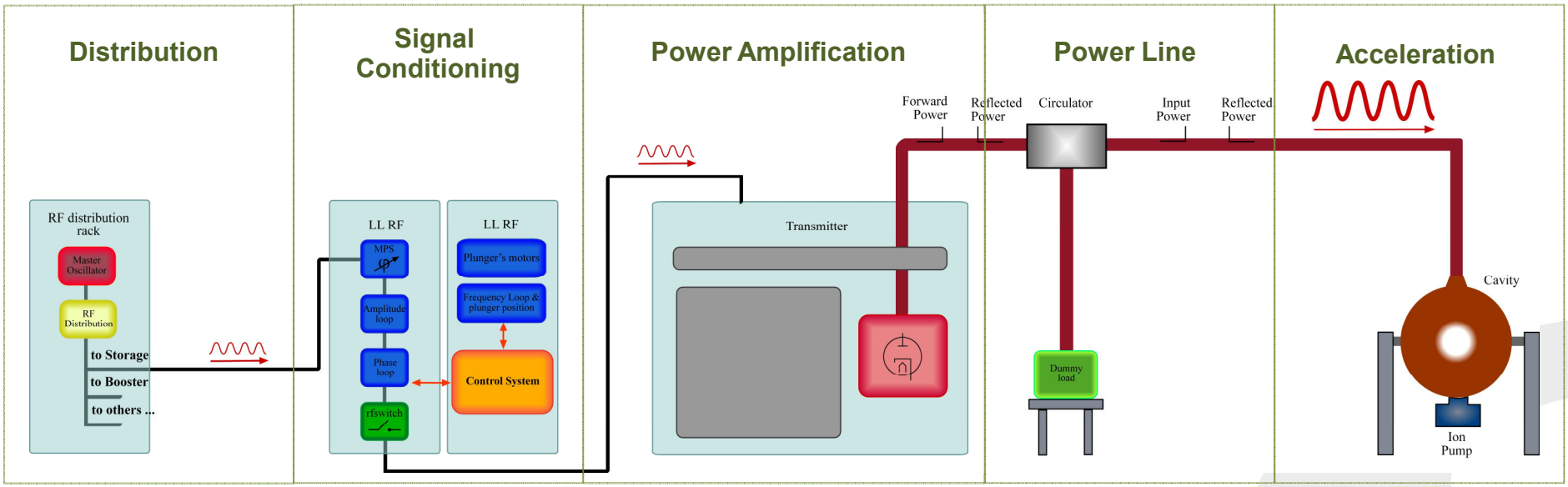
Power dissipation @ Vacc [kW]	120
Power to the beam @ 2.0 GeV [kW]	100
Max Available Power [kW]	310

Booster

1 station

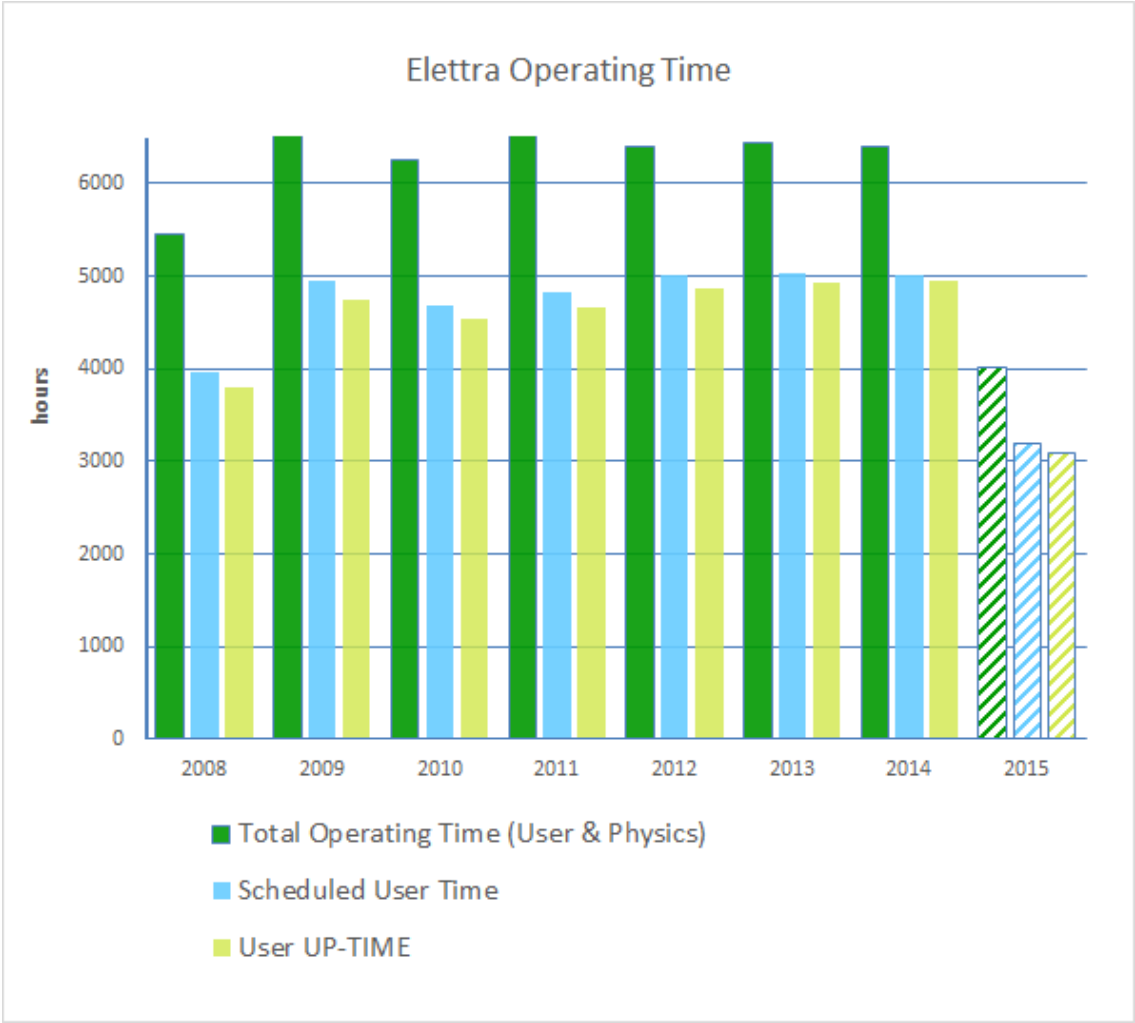
5 cells Petra type cavity
1x60 kW klystron plant

Power dissipation @ Vacc [kW]	14
Power to the beam @ 2.5 GeV [kW]	2
Max Available Power [kW]	55



Elettra UP-TIME

- ✓ Statistic shown from 2008 (full energy injector)
- ✓ **Top up operation** from 2010: at beginning the machine achieved the top up for 95% of the operating time, now **more than 98%** of the operating user time
- ✓ Typically **power outages** are less than 2% of the total number of failures, but they weight more than 30% of down time
- ✓ Mean failure duration ≈ 1.5 hour
- ✓ So far, **user UP-TIME > 95% goal always achieved**, but statistic does not include electrical grid failures/outages
- ✓ Y-2015 statistic data up to August

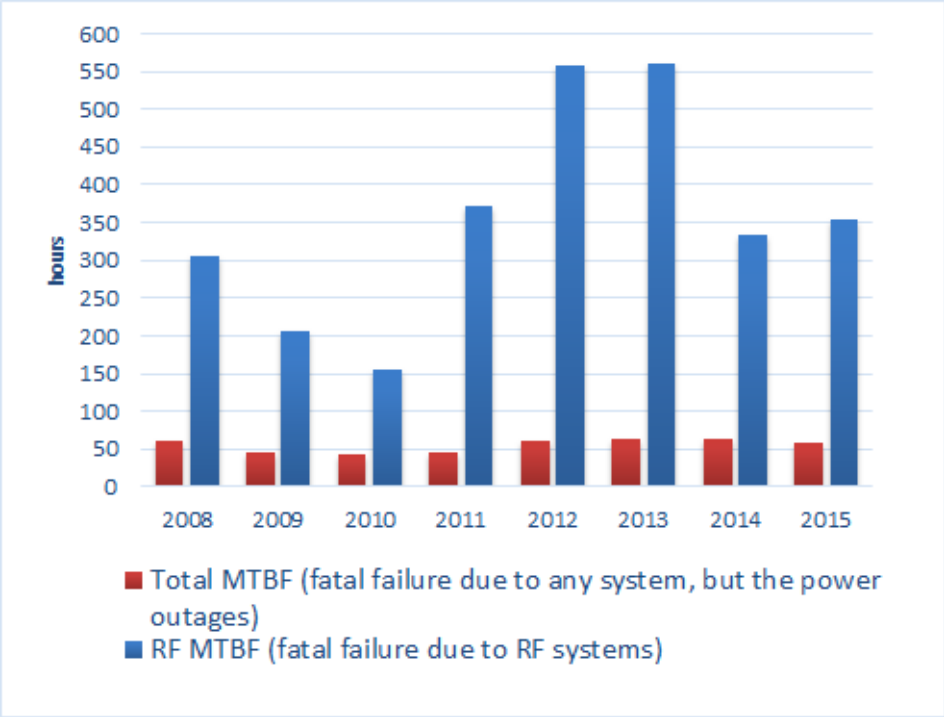


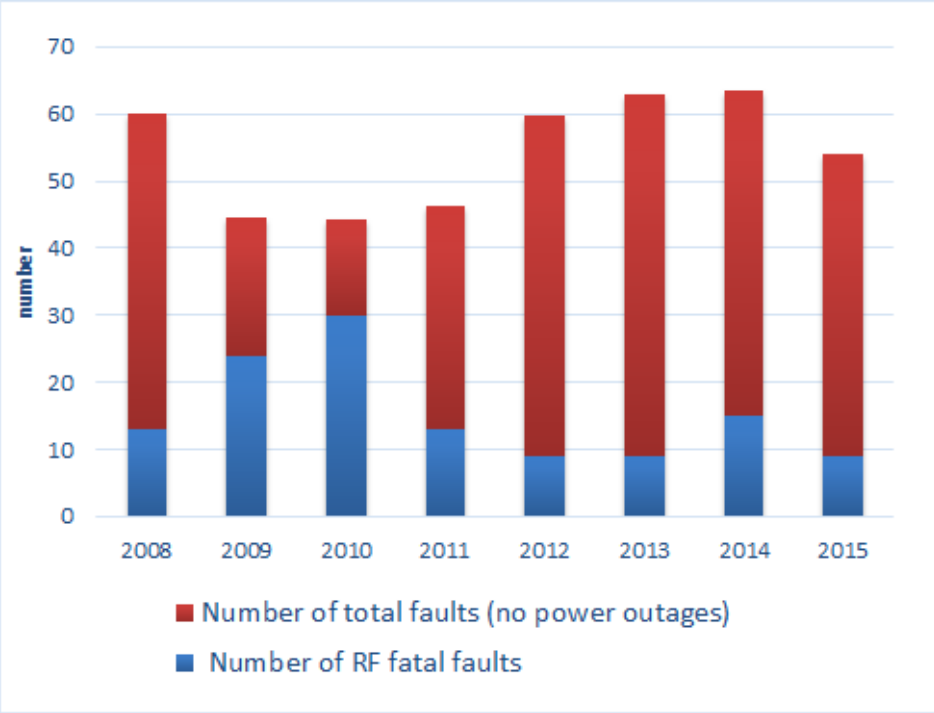
MTBF

- ✓ 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%).
- ✓ Top Up downtime not yet an issue.
- ✓ *2015 data up to August*

Average RF MTBF **≈ 355 hours**

Average number of RF failure **≈ 16/year**

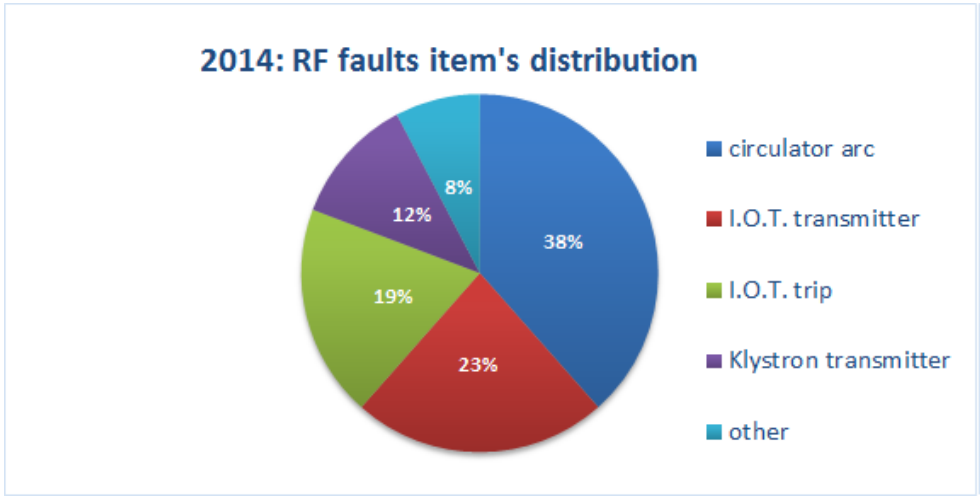


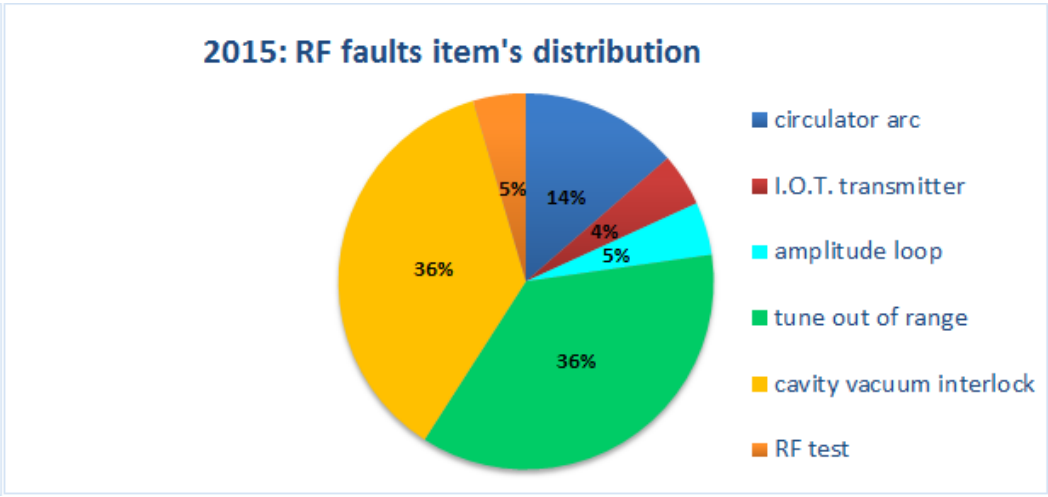


RF Fault Survey

Up to 2014: Main RF failure due to the POWER COMPONENTS, I.O.T.s, Transmitter's Hardware & Circulator Arc.

In 2015: The RF power components almost disappear in the fault item list to let room for the "cavity vacuum interlock" and "tune out of range".





- Cavity vacuum never due to the hardware or real vacuum troubles!
- "Tune out of range" means the tuning feedback diverges and brings the tuning to the limit range

RF Fault Survey

"Tune Out of Range" Fault:

- It started after the new electronic board was installed (phase detector dynamic range > 50 dB)
- It occurs randomly on each cavities, no preferences
- When happen it is always at beginning of new injection, after some beam losses, causing some delay of injection (the cavity shall be tuned back manually and it is downtime). Sometimes it happened in coincidence with a beam loss due to cavity vacuum trip

Action: haunting what's happening with a scope monitor (so far …nothing…) and new board to " blind" the phase detector for few msec in coincidence with sudden and abrupt cavity phase variation.

"Cavity Vacuum" Trip:

- This trip always kills the beam, sometimes it was causing also "tune out of range" fault on a second cavity
- It occurs mostly on cavity #3 and #8.
- Half of the time it happened suddenly, half of time at a certain current level during injection, but it was not reproducible
- They happened during 2 runs: from March to June

Action: Very likely these trips are due to some instability, but its detection was below the monitoring/ recording capability. Need of fast detector on RF signals together with current signal. So far no more fault from September.

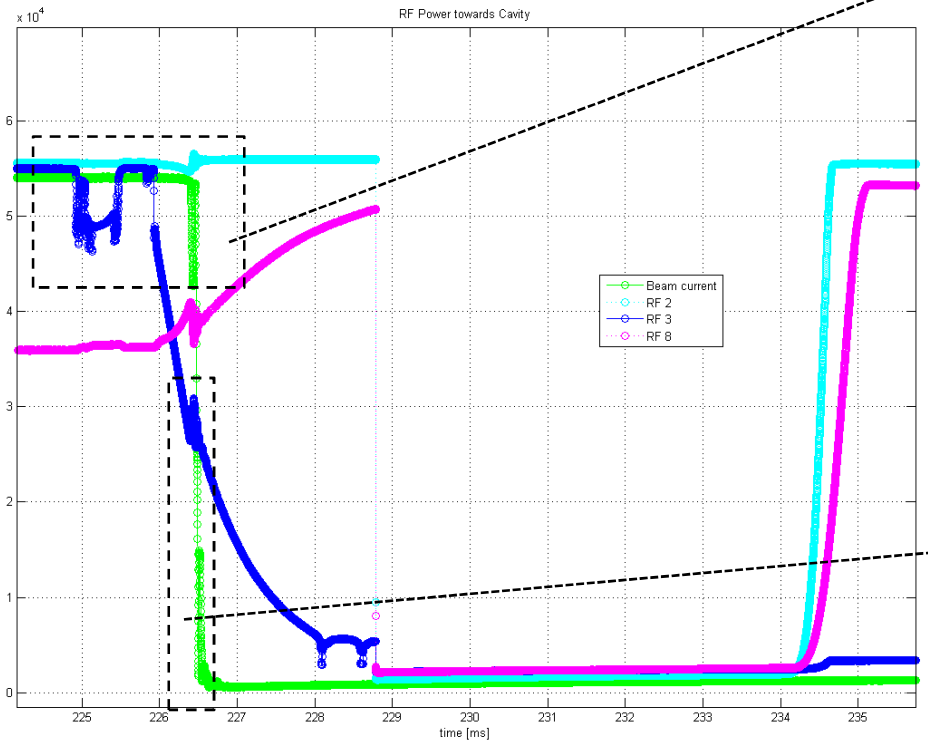
Even if Elettra has a really huge amount of operating hours it still surprising us!

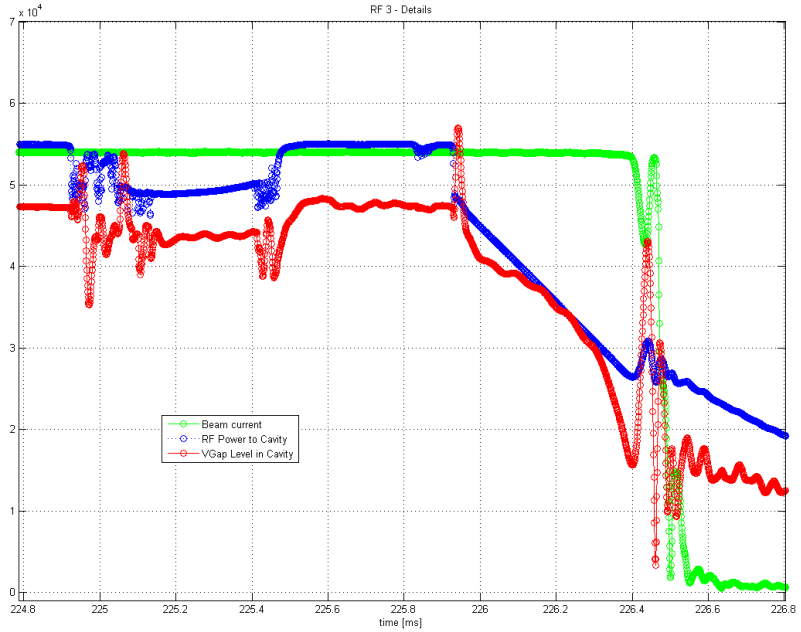
Beam Dump Monitor and RF Signals

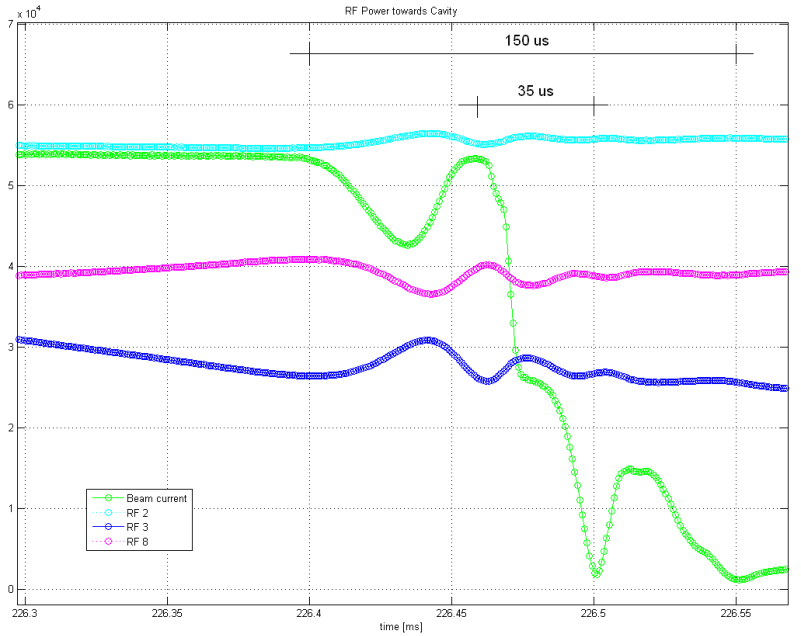
To monitor and analyse the beam dump it has been developed in house a board to sample analogue signals synchronized with the beam current drop: 1 sample/1 turn (1.16 MHz frequency) and data log length > 400 msec (Carniel et al., Diagnostic Group)

So far only the RF signals are monitored (forward power, cavity signal sample and reflected power).

Beam loss due to cavity RF#3 vacuum interlock

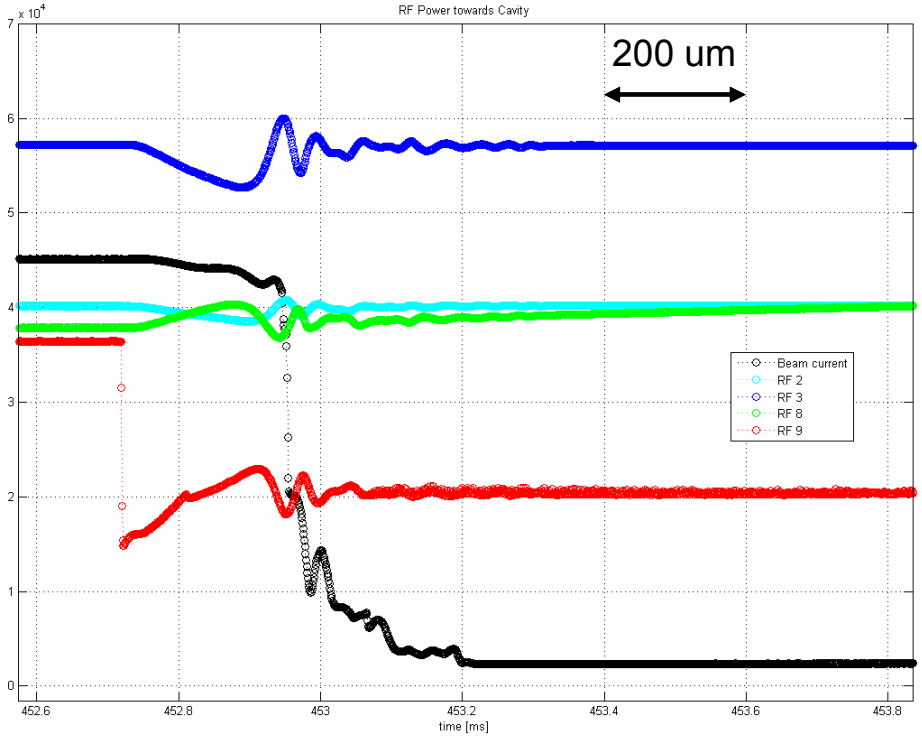


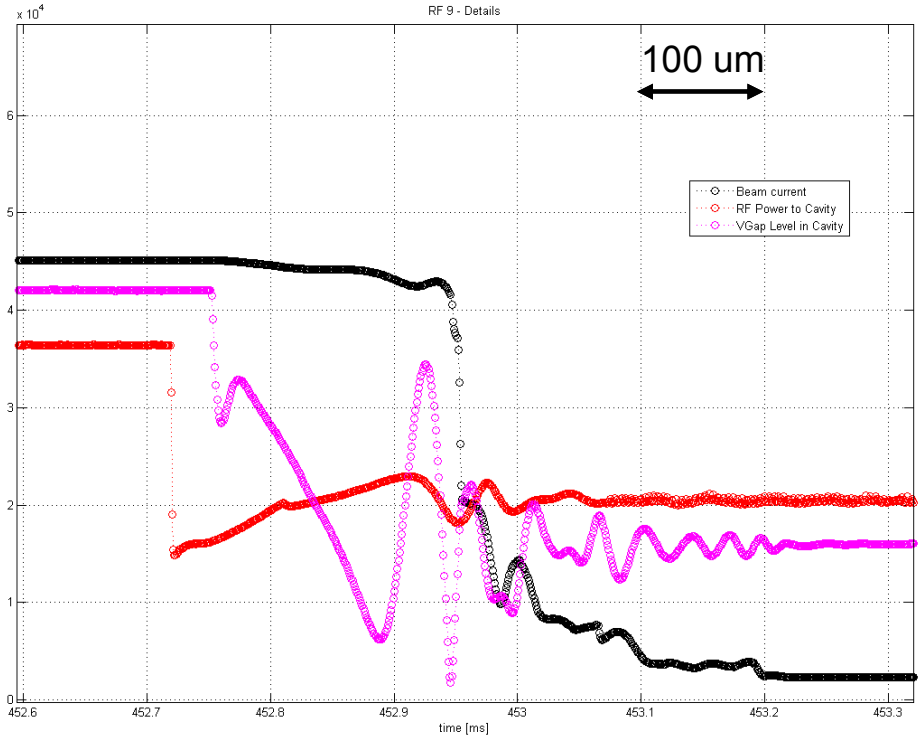




Beam Dump Monitor and RF Signals

Beam loss due to hardware fault of one of the RF #9 I.O.T. transmitter





Preliminary data!

Some calibration of the acquisition data is still required,

but it is **a really useful tool to check the RF performances**!

RF Power Source Statistic

Transmitter	Tx-A		Tx-B	
Heater time*	**46300**		**45900**	
Tube	E2V D2130		E2V D2130	
serial number	302 - 1017		368 - 1208	
installation date	2010 June		2012 June	
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*	**29400**	0	**19120**	0

* August, 2015

150 kW twin I.O.T.s based transmitter, in operation from 2006

Output power is the sum of 80 kW + 80 kW by means of a switchless WG hybrid combiner

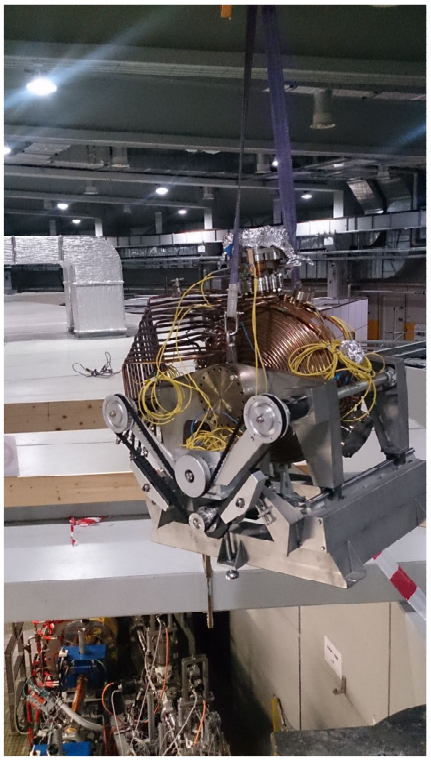
RF Station	klystron	s/n	tube hours*	heater hours*
Booster	K3672 BCD	1083-0351	**39760**	**113670**
RF #2	K3672 BCD	1184-0823	**35040**	**127030**
RF #3	YK1256	14105.265	**22740**	**128620**
RF #8	K3672 BCD	1184-0823	**34850**	**128130**

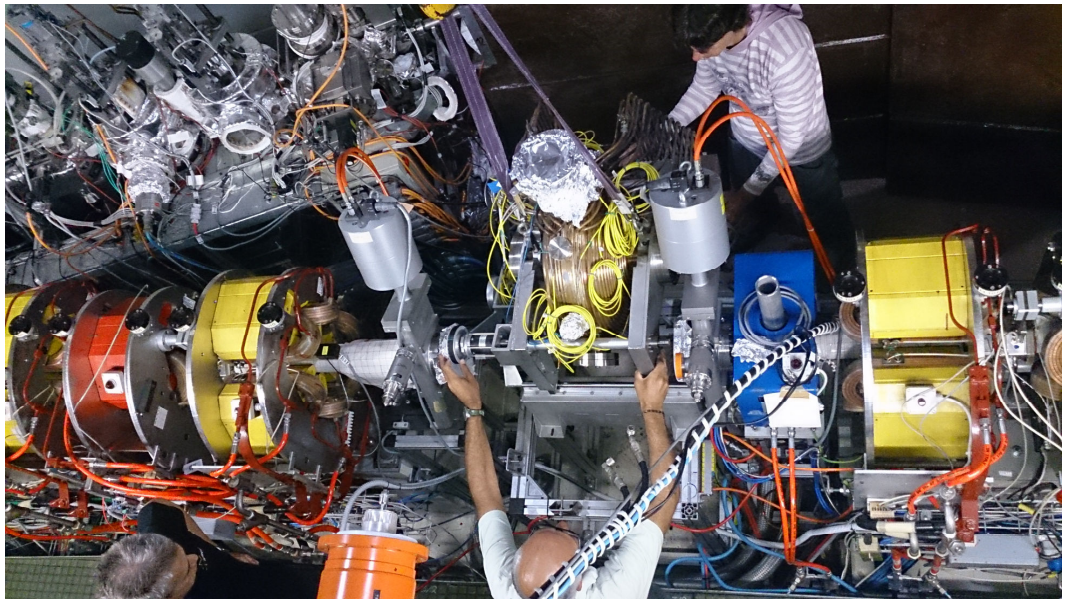
* August, 2015

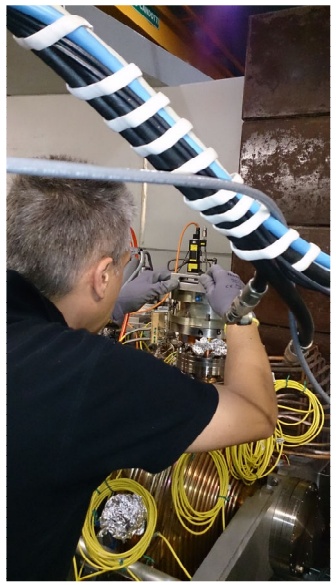
Cavity replacement

June 2015

- Replacement of the RF#2 cavity. It was the oldest one, installed in the storage ring in 1994.
- Three working weeks, from removal to full RF power conditioning (cavity already conditioned in the RF lab)
- RF#2 vacuum =2.9 10^{-9} mbar after 1500 hours with beam – others cavities's vacuum ≈ 1.3 10^{-9} mbar

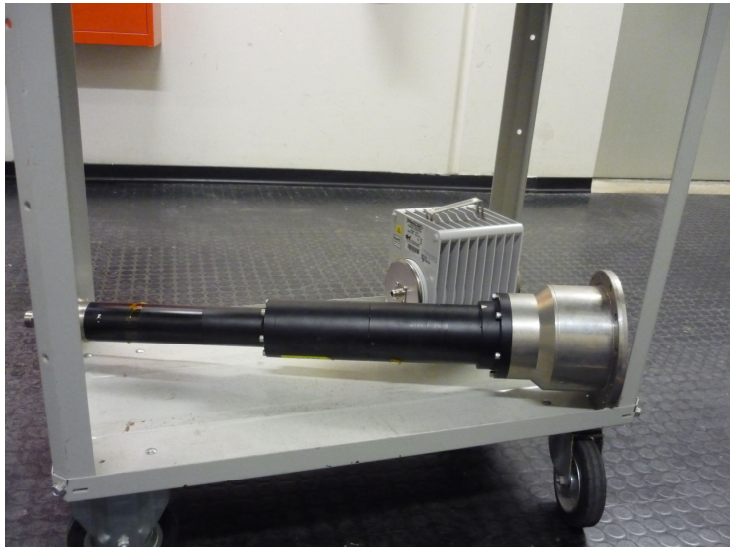


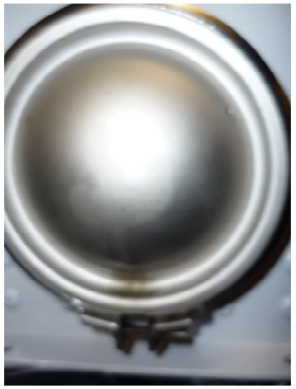


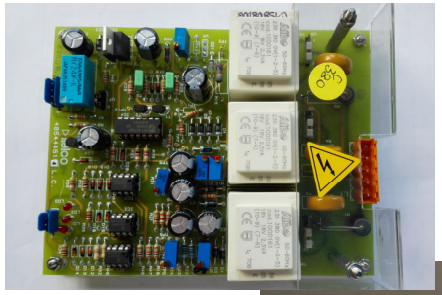


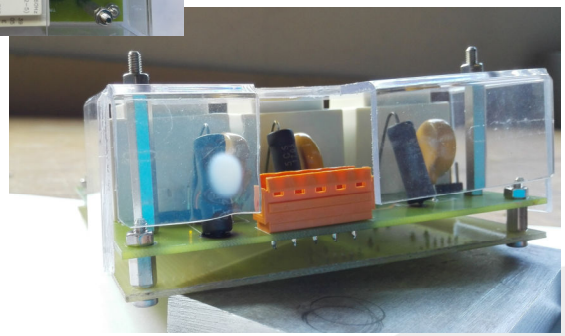
At Elettra all the cavities are now "new", with a power dissipation capability > 66 kW (V acc > 650 kV)

WHEN it does not work…









Transmitter's items, Klystron and I.O.T. snapshot coming soon!

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Conclusion

- Maintenance and servicing it is a must for so old machine!
- Revamp the electronic may prove not so quite straightforward
- Never forgot the beam dynamic, even tough you'll think every thing is well known
- Control room team shall have a continuous training, at least one/year
- Cavity replacement really straightforward!
- Several collaborations in progress:
  - *four Elettra cavities for the SESAME facility (Jordan – Middle East)*
  - *one Elettra cavity for the INDUS II facility (Indore - India)*
  - *ESS collaboration for the spoke cavity transmitters*
- The Elettra 2 project (Ultimate Storage Rings 2.0 GeV 400 mA) is in progress
- The RF power project: news very soon…

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Thank you!

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