Normal Conducting RF Activities at ELETTRA

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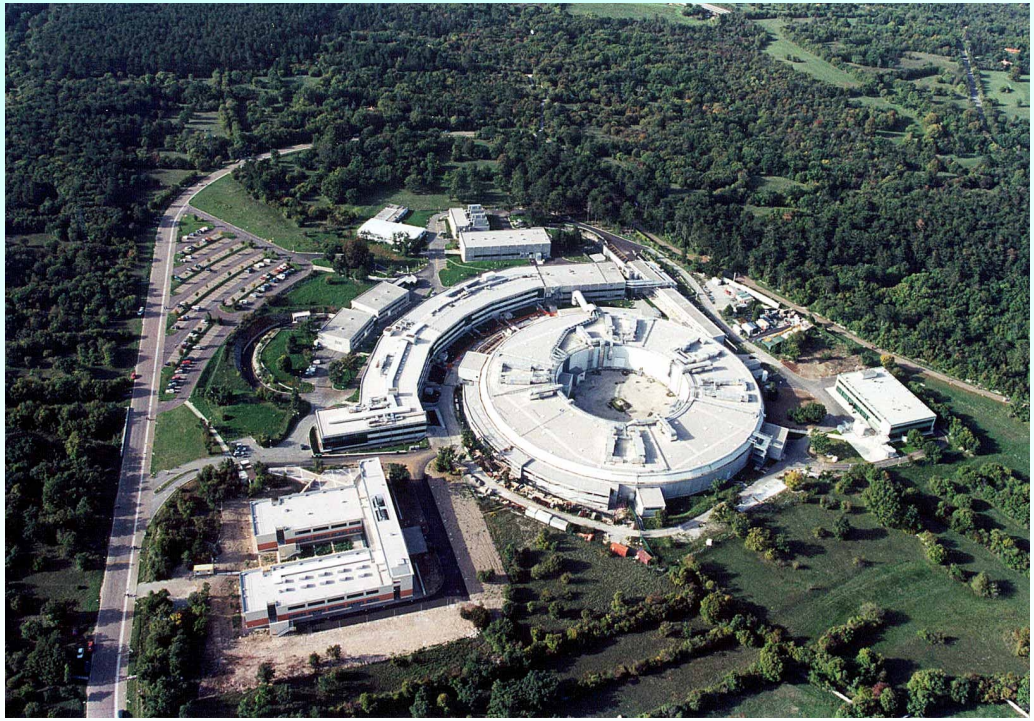


Summary

- *Storage ring RF system operation*
- *Booster RF system*
- *RF upgrade project*
- *Status and outlook*

7th ESLS RF Meeting
Karlsruhe, October 16-17, 2003

Overview

- Activities of the ELETTRA RF group on normal conducting RF are mainly concentrated on:
  - Maintenance, servicing and improvements of the **existing plants**.
  - Design and development of the new **Booster RF system**.
  - Design and development of phase A of the storage ring **RF upgrade project**.

- **Progress of new projects since end of last year have suffered due to funding difficulties.**

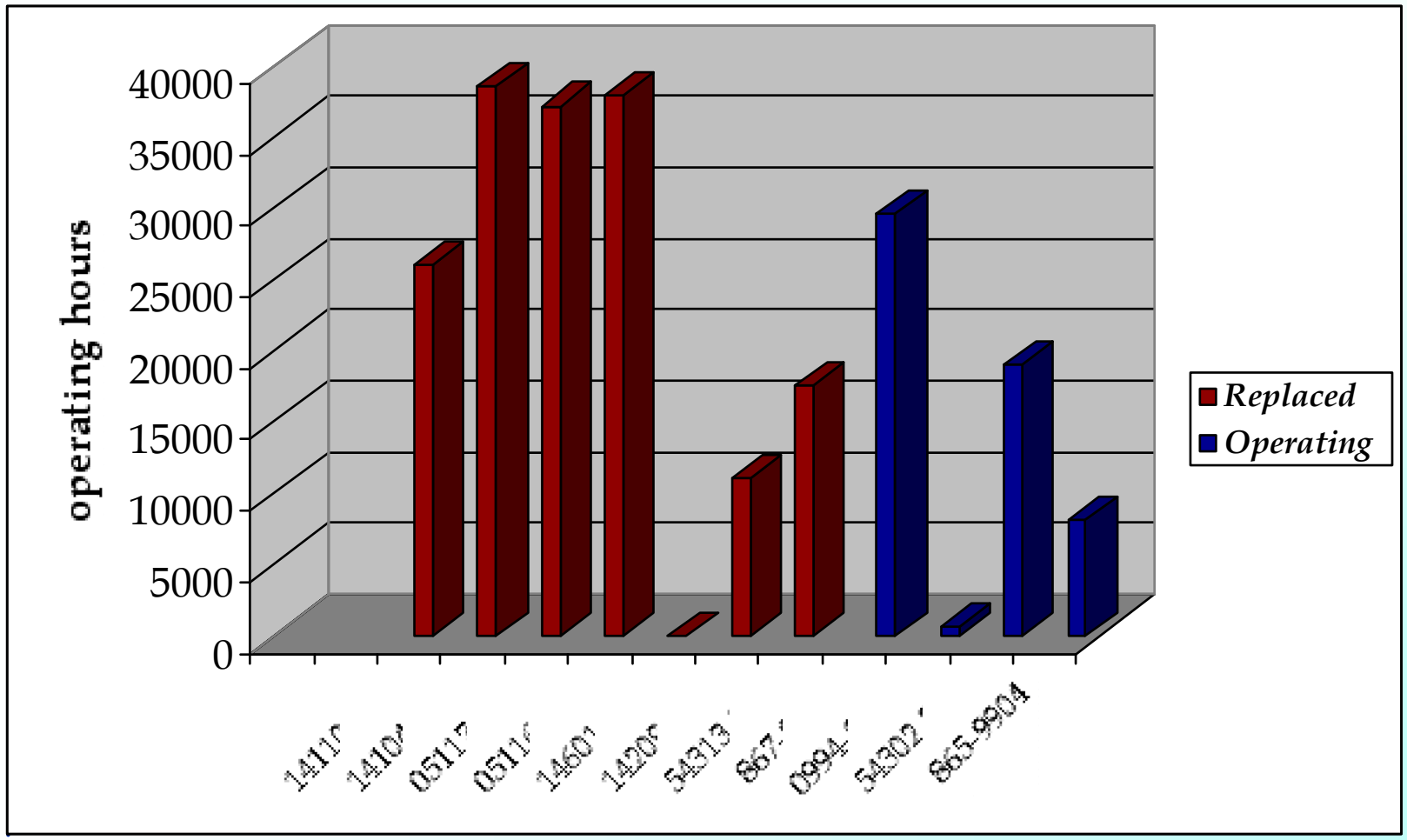
- Working to maximise use of available funds.

Storage ring RF system (1)

- Storage ring RF system is in operation from **October 1993**.
- Operating hours of the plants are between **56000 and 57000** hours.
- Users downtime due to RF system is typically in the range between **5 to 7 %** of the total users downtime.
- To summarise our experience:
  - **Cavities** have performed very reliably.
    - Two couplers were replaced.
      - One after 34500 operating hours due to a water leak.
      - One after 49000 operating hours due to a crack in the ceramic following a major fault in the coaxial line.
  - **Low level electronics** is very reliable.
    - Almost no failure.
  - Still we are suffering of random **circulator** arcs.
  - **Coaxial transmission lines** have given some major troubles especially due to discharge and deterioration of the dielectric disks.
    - Four events, but serious.
    - To understand if this could be related to HOMs.
  - **Amplifiers** have performed reliably, especially after having solved the problems of transformer overheating and improved the preventive maintenance.

Storage ring RF system (2)

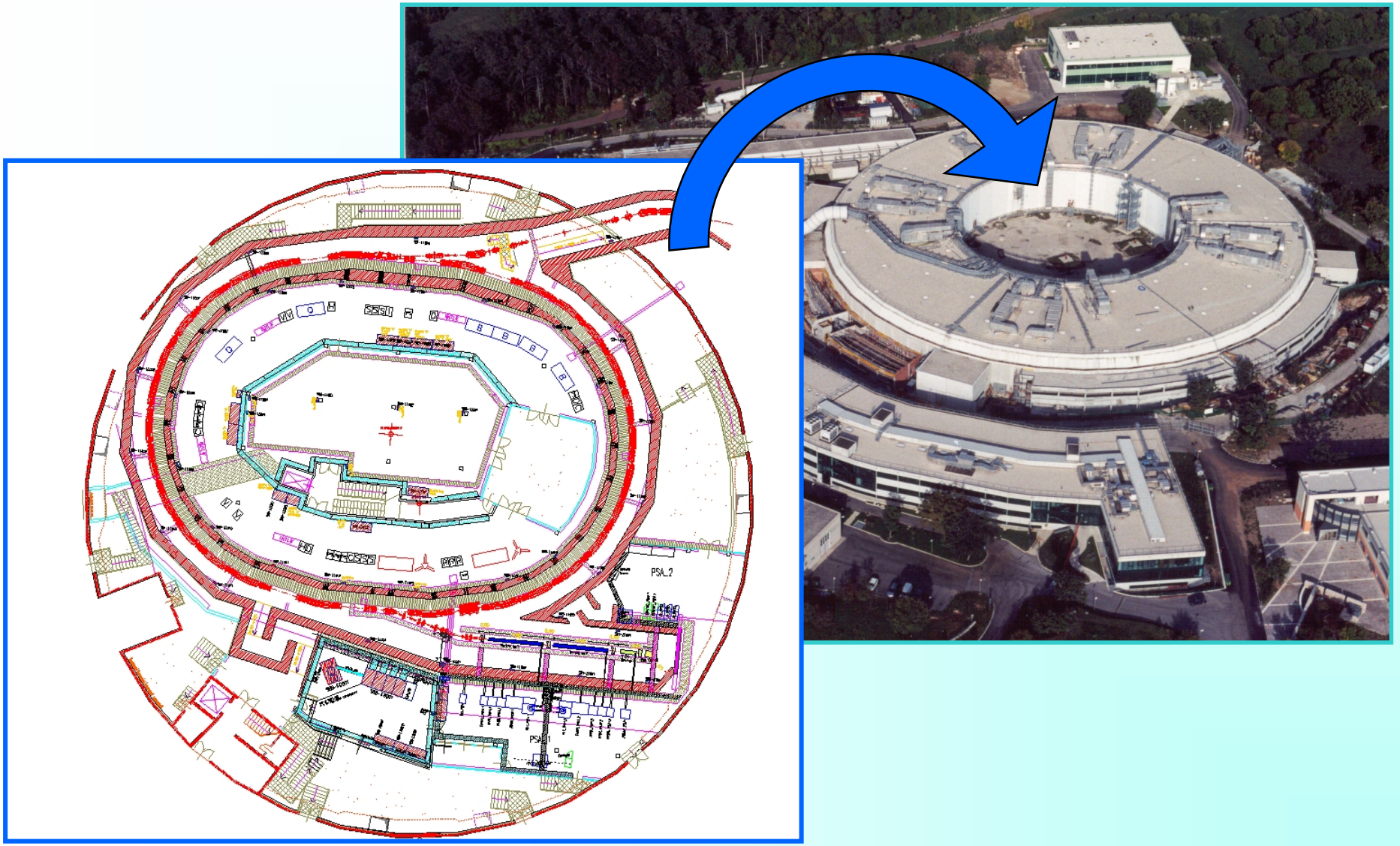
- All the original klystrons have been replaced.
  - Generally due to loss in emission.
  - Decided to replace them around 30000 hours as a preventive maintenance.



Recall on the booster project

- A full energy injector is now under design to improve reliability and increase the overall efficiency of the facility.
- This will be a **2.5 GeV booster synchrotron**, which can be conveniently located in the open space inside the storage ring building.
- Injection to the booster will be performed with a 100 MeV linac.
- The possibility of top-up injection is also planned.

Recall on the booster project



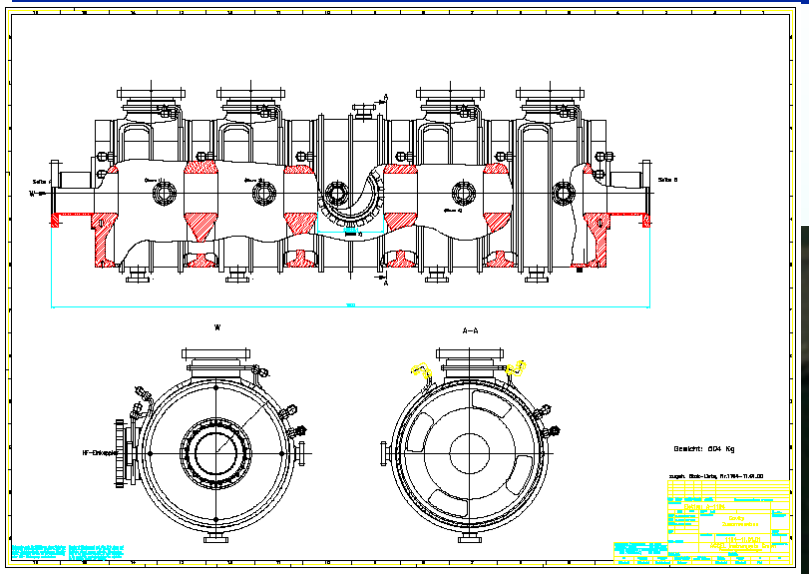
Booster RF system parameters

MACHINE PARAMETERS		
Beam Energy	**2.5**	**GeV**
Energy loss/turn at 2.5 GeV	388	keV
Beam current	10	mA
Harmonic number	198	
Revolution frequency	2.524	MHz
Momentum compaction factor	4.3300E-02	
Natural energy spread	7.18E-04	
Damping time (long)	2.6	msec
Rep. frequency	**3**	**Hz**
RF PARAMETERS		
RF frequency	**499.654**	**MHz**
Synchrotron frequency	51.00	kHz
Quantum lifetime (2.5 GeV)	1.4	sec
Overvoltage factor	2.16	
Total effective RF voltage	**840.0**	**kV**
Energy acceptance	3.10E-03	
CAVITY PARAMETERS		
Cavity shunt impedance (TT corrected)	14	Mohm
Unloaded quality factor	29000	
Cavity power	**25.2**	**kW**
Beam power	3.88	kW
GENERATOR POWER	**29.08**	**kW**

Booster RF system

- **CAVITY**
  - One 5 cell DORIS type cavity built by ACCEL.
  - Ordered in April 2001.
  - Delivered in May 2003.
- **POWER PLANT**
  - The power plant will be the 60 kW power plant (amplifier, circulator, transmission lines) which will be replaced following the first phase of the storage ring upgrade project.
  - Already from the beginning the layout foresees the installation of a second power plant in passive operation and connected to the cavity via a coaxial power switch, to allow redundancy.
- **LOW LEVEL ELECTRONICS**
  - Basically the same systems developed for ELETTRA with the upgrades performed for ANKA and SLS.
  - Some developments are needed for the different cavity.
    - Frequency loop driving two pistons.
    - Possible need of a balancing loop.

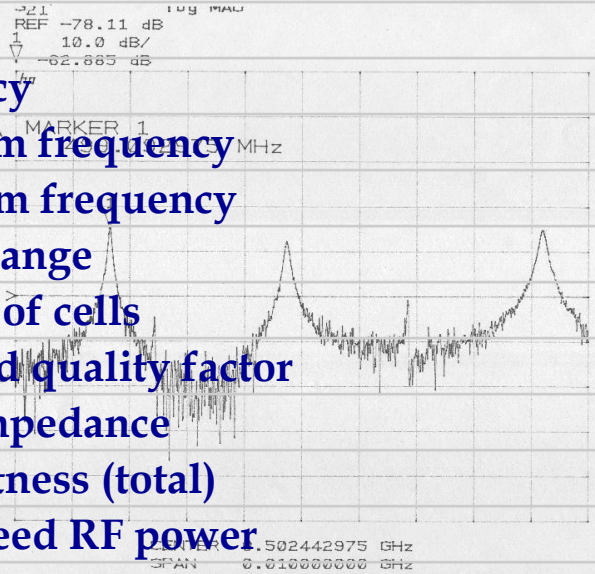
Booster RF cavity (1)

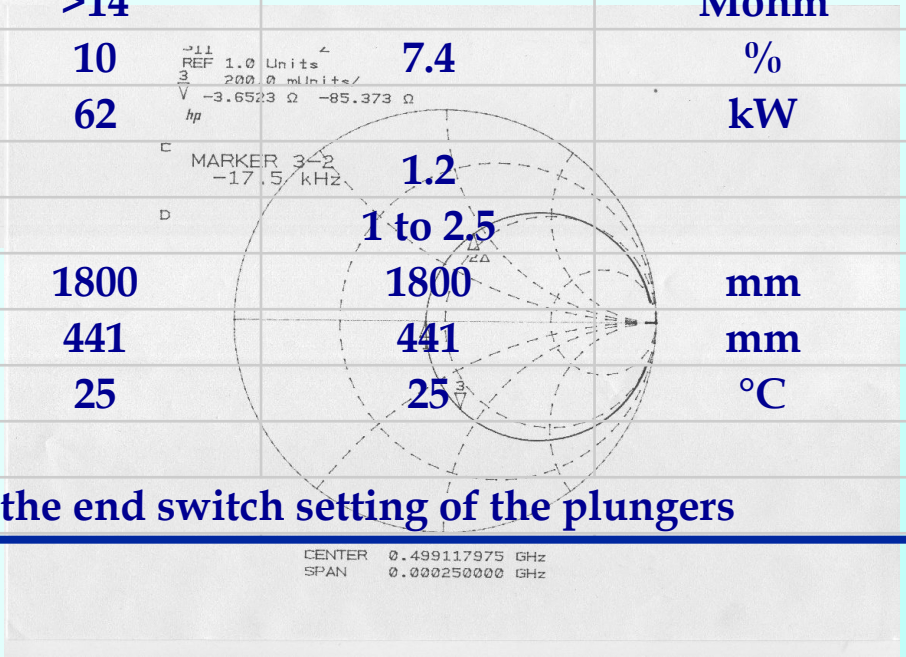


Booster RF cavity (2)

CAVITY PARAMETERS	Specified	Measured	
Frequency	499.654	499.654	MHz
Minimum frequency		499.273	MHz
Maximum frequency		499.918	MHz
Tuning range	800	645*	kHz
Number of cells	5	5	
Unloaded quality factor	29000	29500	
Shunt impedance	>14		Mohm
Field flatness (total)	10	7.4	%
Guaranteed RF power	62		kW
Coupling		1.2	
Coupling range		1 to 2.5	
Length	1800	1800	mm
External diameter	441	441	mm
Input cooling water temperature	25	25	°C

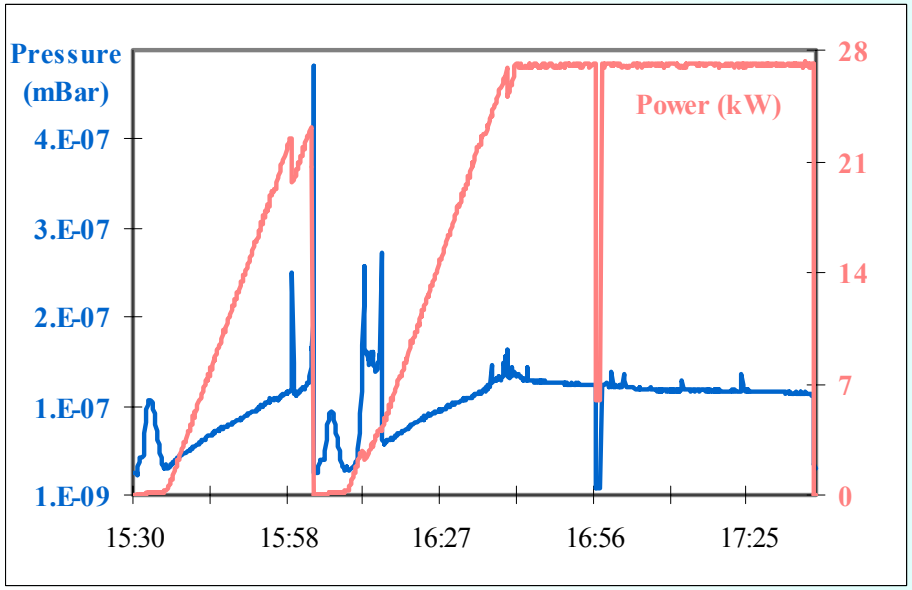
*Note: range can be expanded by readjusting the end switch setting of the plungers

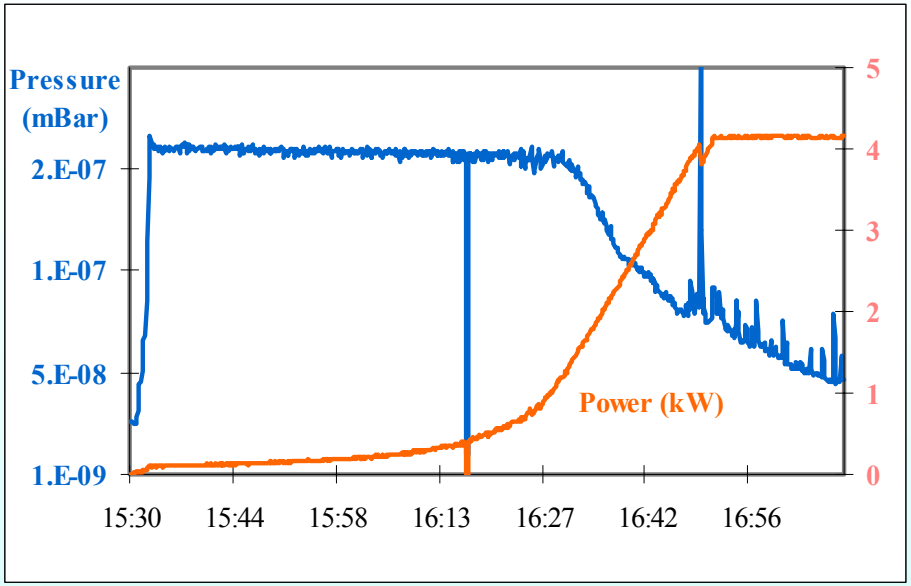




Booster RF cavity (3)

- Cavity conditioning has started at half September.
- According to ACCEL instructions:
  - Cavity was previously bake out at 120 °C.
  - Vacuum interlock trip set to 5 E-7 mbar in the first phase (up to 25 kW). Then it will be set to 1 E-7 mbar.



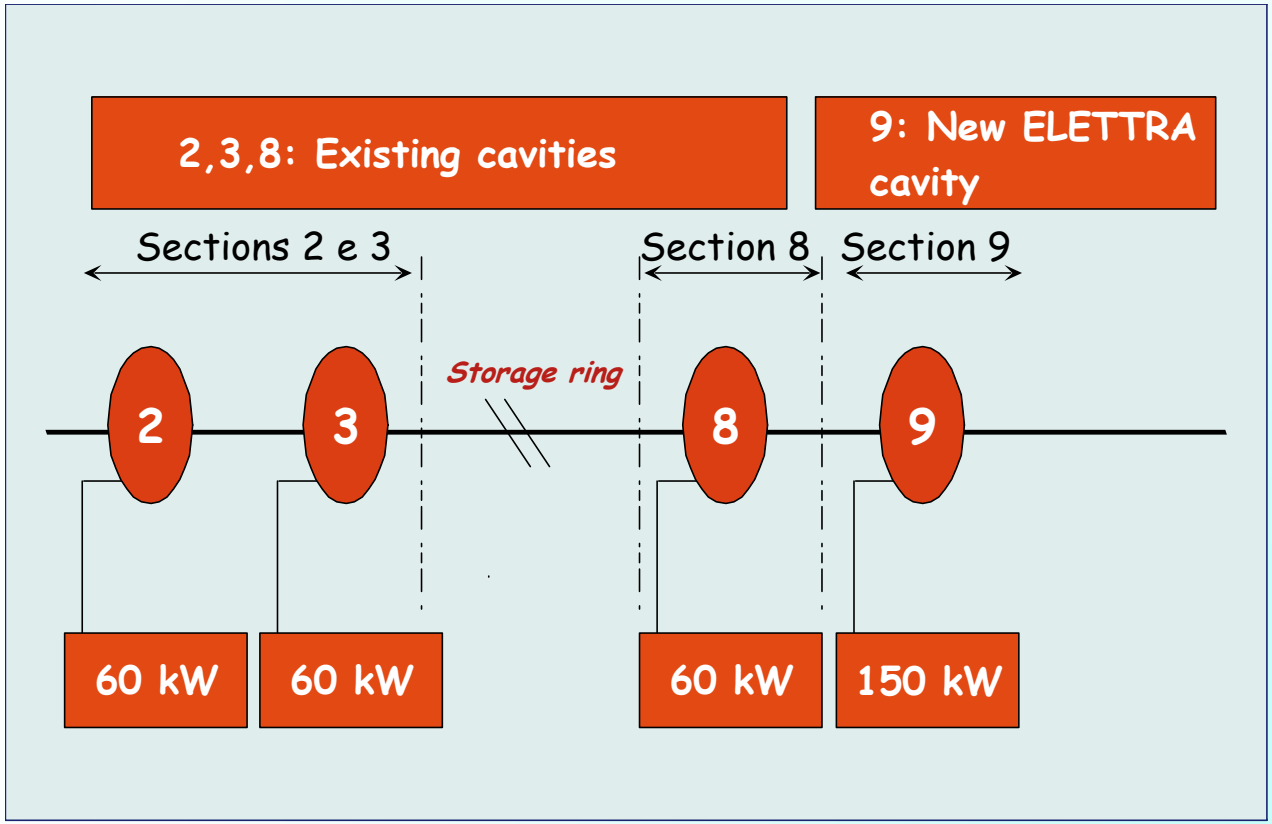


- Conditioning is steadily proceeding, although quite slowly .
- Typical vacuum levels:
  - No RF 10^{-10} mbar range
  - Pulsed RF $1.5\ 10^{-7}$ mbar
  - 100 % dc RF $5\ 10^{-8}$ mbar
- Multipacting problems were encountered up to 10 kW

- **Presently we have reached 27 kW cw.**

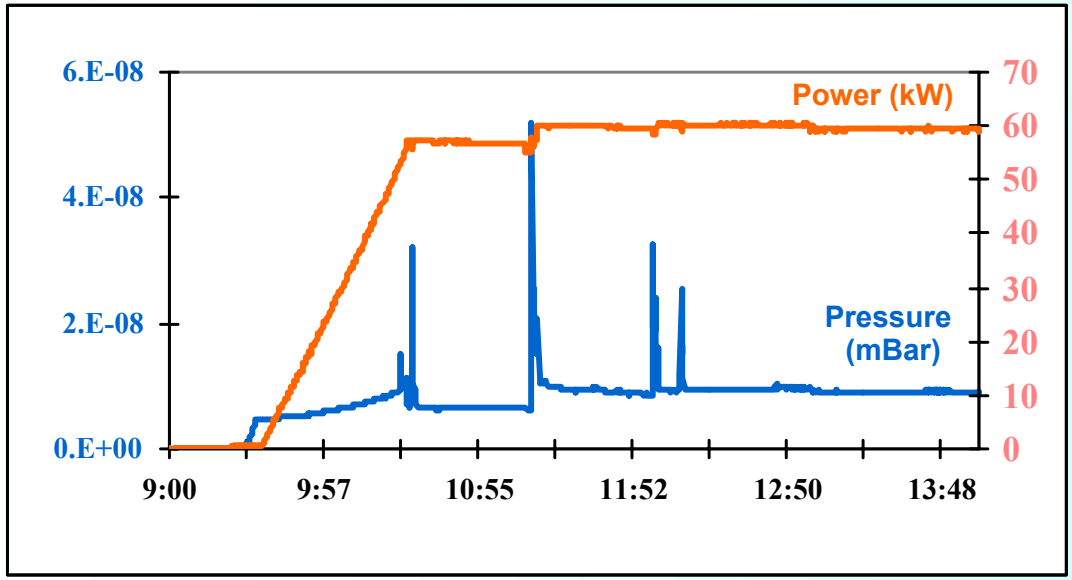
Storage ring RF upgrade recall

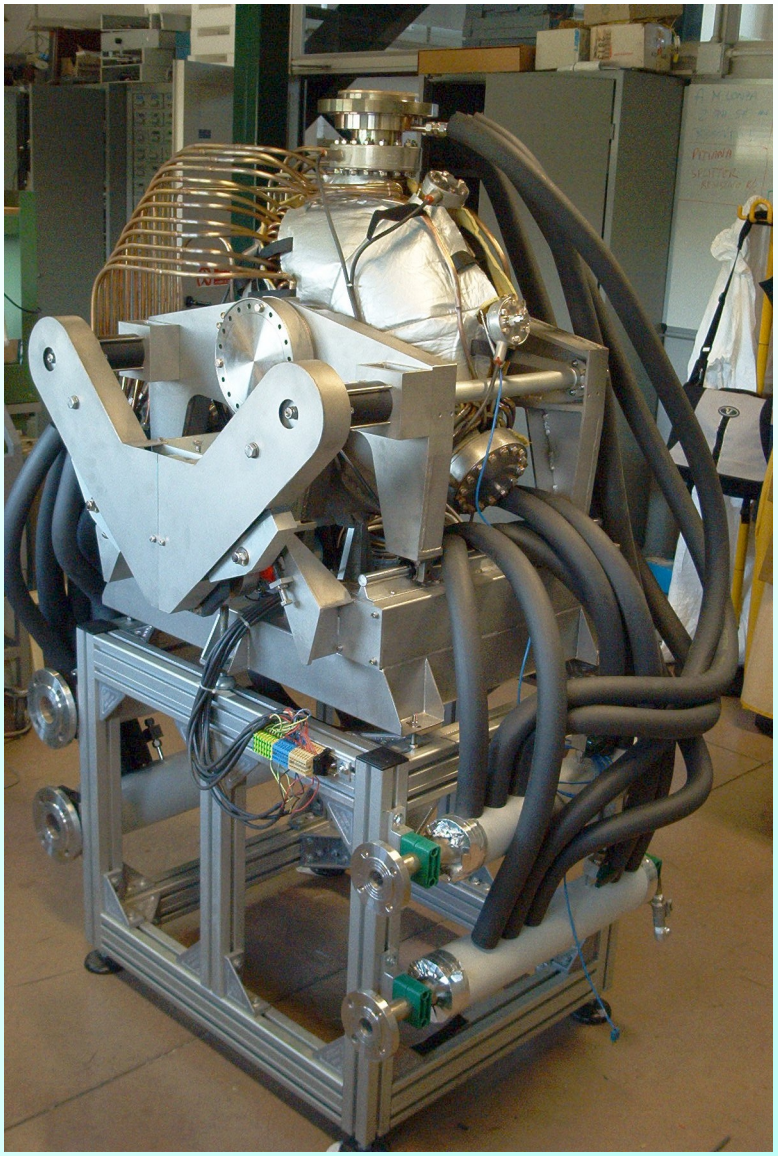
- A project for the upgrade of the existing RF system was launched during year 2001, in order to assure:
  - An increase of the available power for the beam, also in view of future installation of insertion devices and increase of the stored beam current and energy.
  - A higher beam lifetime.
  - A wider operating margin for the operation of the RF system.



Upgrade cavity (1)

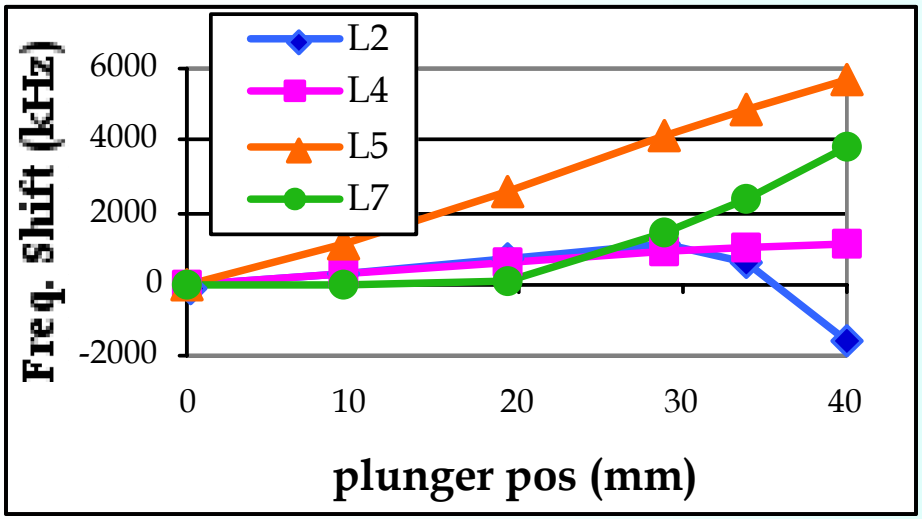
- The new cavity similar to the ones we have provided to ANKA and SLS has been measured and fully characterised in our laboratory.
- It has been fully conditioned in the laboratory test stand up to 60 kW.
- The first conditioning required 80 hours. Then the cavity was vented for measurements and reconditioned. This time the cavity reached the full power in less than 20 hours.

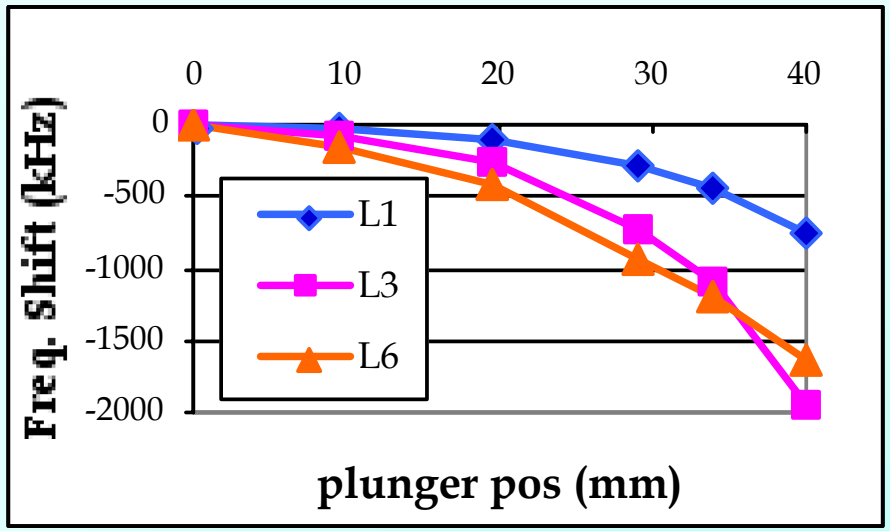




Upgrade cavity (2)

Fundamental mode parameters		
Frequency	499.654	MHz
Coupling	2	
Q_0	41800	
R_{sh}	3.39	Mohm





➤**Installation in the ring is foreseen during next November three weeks shutdown.**

Power amplifier (1)

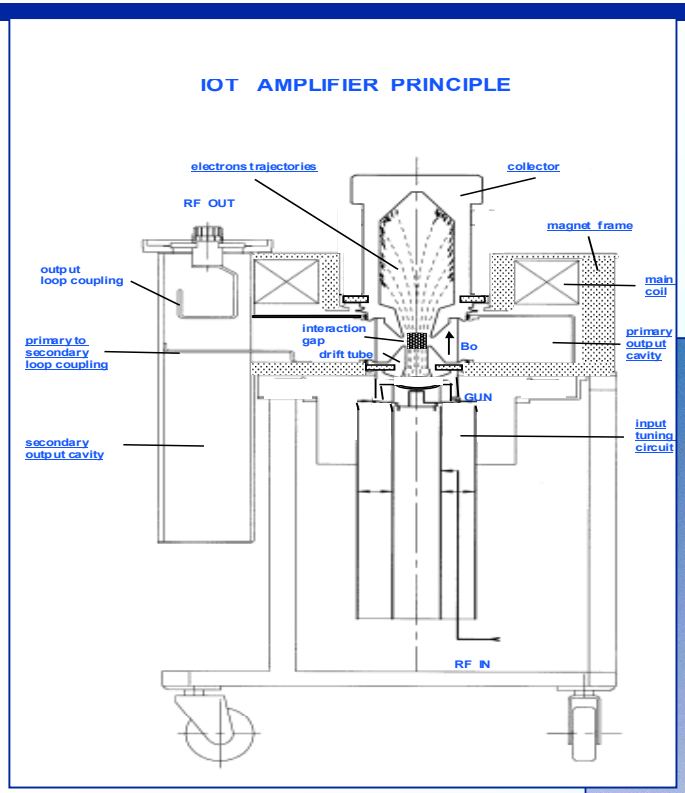
- The call for tender of the power amplifier was launched during the third four month period of last year.
- Scope of the call for tender was the supply of **one complete power amplifier** (transmitters, combining system and controls).
- Two options were required:
  - **Option A: 150 kW cw** amplifier realised combining **two 80 kW IOTs**
  - **Option B: 140 kW cw** amplifier realised combining **three 50 kW IOTs**
- Offers were received from **7 companies** :
  - Three Italian
  - Two American
  - One Swiss-French-American
  - One German
- Four companies quoted both the options, one only option A and two only option B.
- IOTs proposed:
  - For option A: TH790
  - For option B: either TH770, CHK2500W or IOTD2100.

Power amplifier (2)

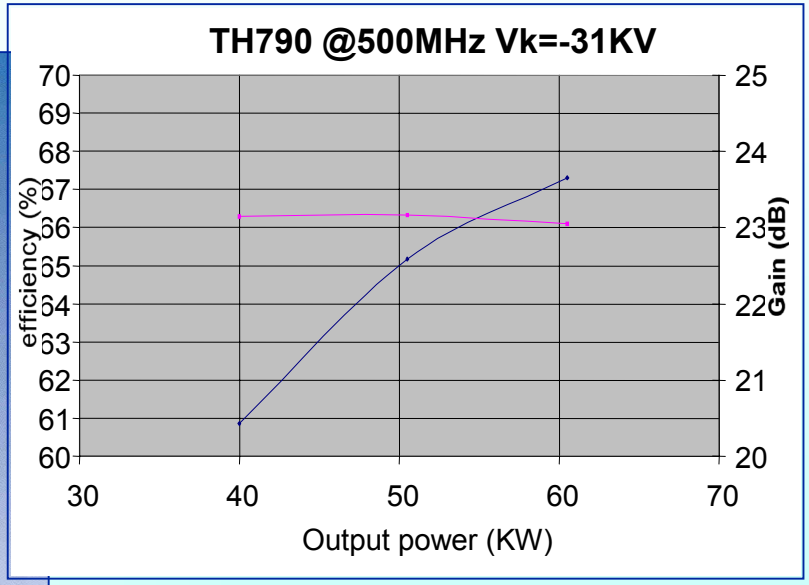
- After a detailed evaluation of the proposals we decided to adopt **option A**.
- Main reason which drove this choice are:
  - **Space**
    - The amplifier can be installed between two columns of the service area in front of the existing amplifier.
  - **Costs**.
  - **Higher output power** at the system output.
- Note: the only company that presently manufactures a 80 kW IOT is Thales Electron Devices, although the other companies are now performing tests to push their tubes to higher power.
- Amplifier will be designed in order to allow the installation of IOTs of different manufacturers.
- The system will be designed to allow the addition of a further unit in the future.

- **Order of the amplifier will be done as soon as the budget situation will be clarified.**

Power amplifier (3)

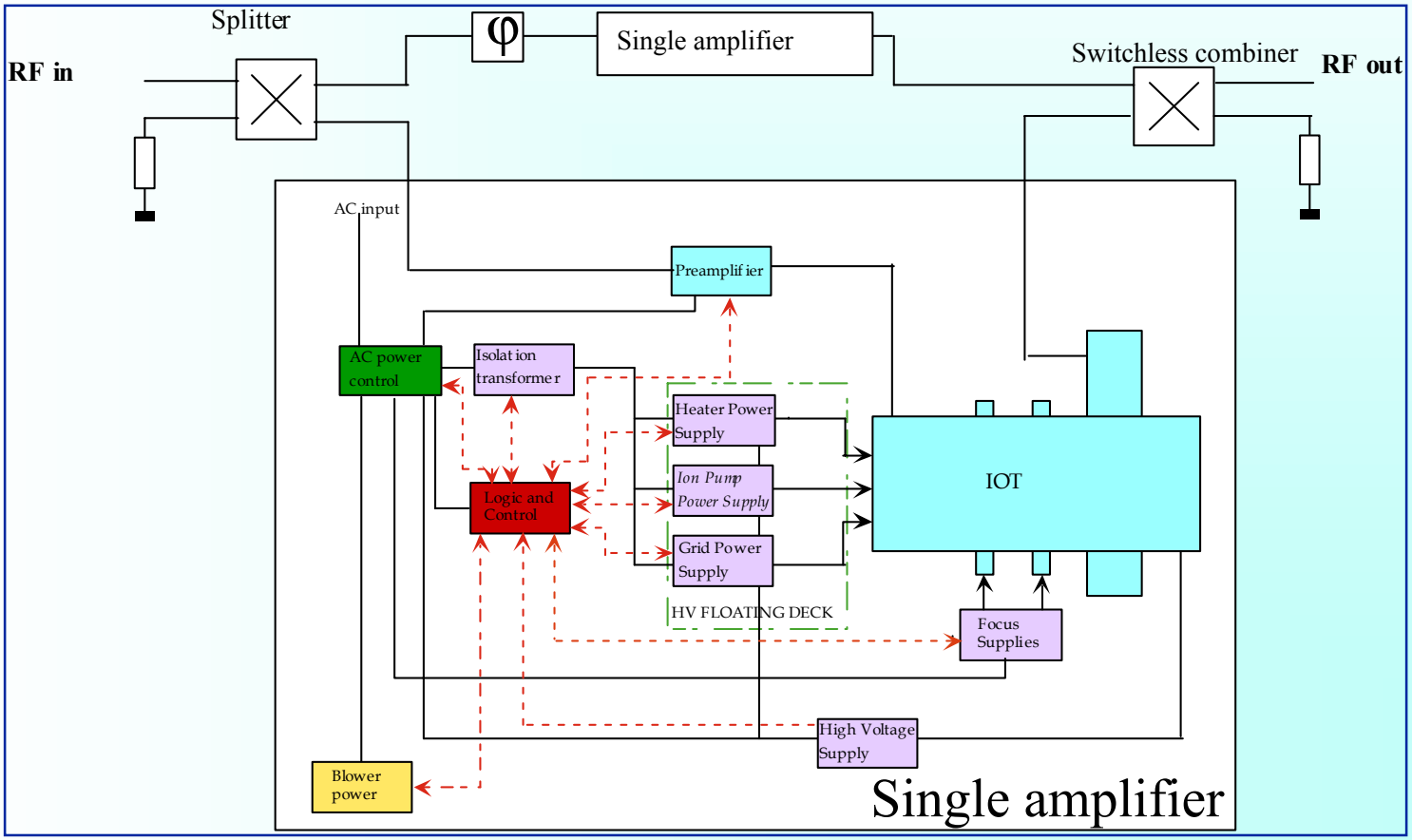


	CW		
	Average power	Efficiency	Beam Voltage
TH 790	80 kW	66%	35.5 kV



Power amplifier (4)

- Power combination will be performed with a switchless combiner
  - 3 dB power loss when one amplifier is out of service.
  - Four modes of operation.
  - It allows hot adjustment of the system.
  - **Maintenance of one amplifier can be done while the other is in service.**
- They are standard components, thoroughly designed and understood



Status and outlook

- **Booster RF**
  - Cavity under conditioning.
  - Power plant and low level system designed.
  - Installation of the booster will start two years after availability of funds.
- **Storage ring RF (present and upgrade)**
  - After 10 years existing system well known and understood.
  - RF upgrade project delayed due to budget restrictions.
    - New cavity will be installed soon.
    - Ready to make the amplifier order when the funds will be available.
    - Study of waveguide runs, modifications to the conventional facilities are continuing.
    - Circulator, waveguides and loads technical specifications are ready.
    - Upgrades to the low level system are being performed in parallel.
    - At the moment the possibility of two long shutdowns is planned during the second half of next year for the installation of the amplifier.