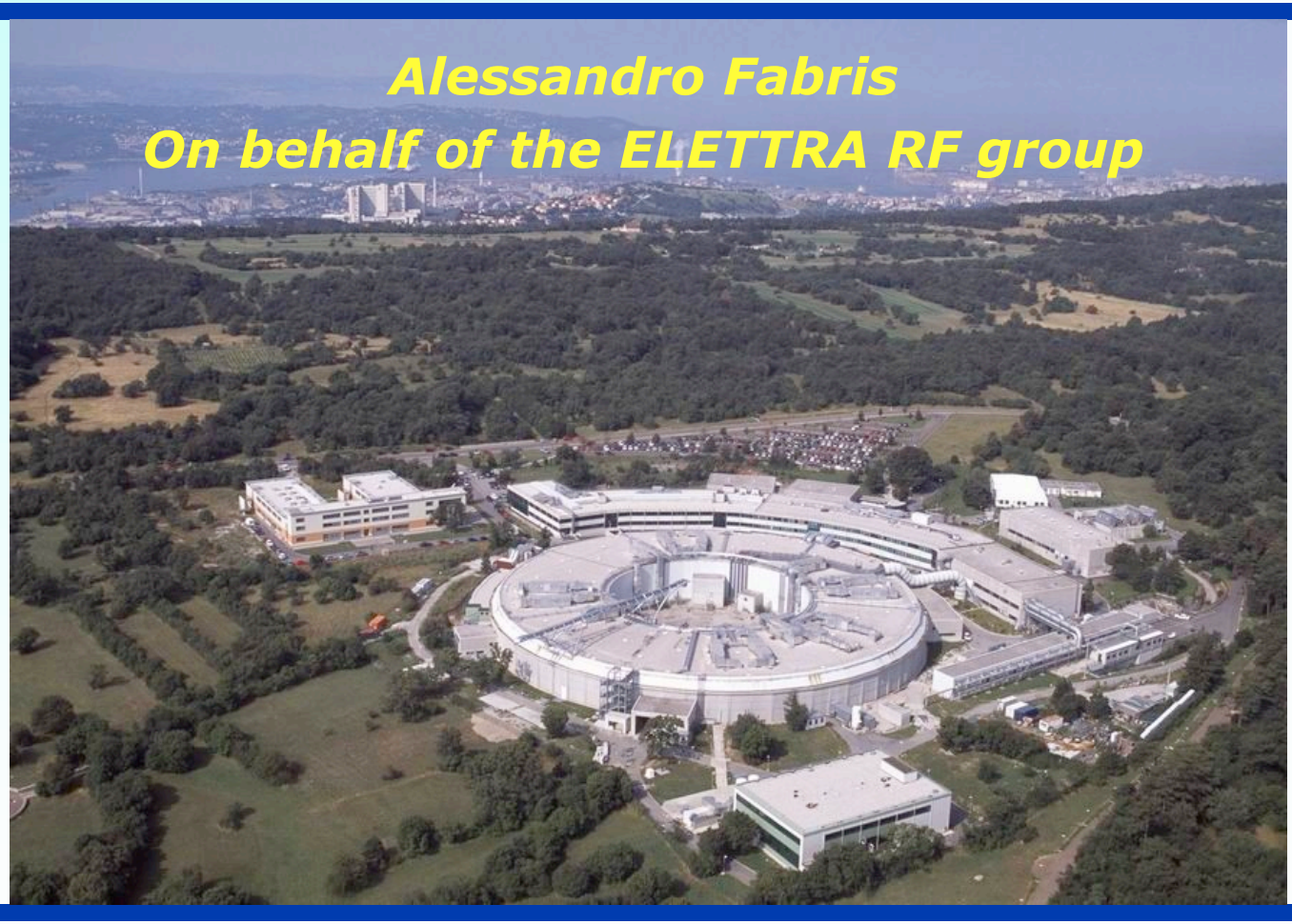
150 kW Power Plant for the ELETTRA RF System Upgrade

Alessandro Fabris
On behalf of the ELETTRA RF group

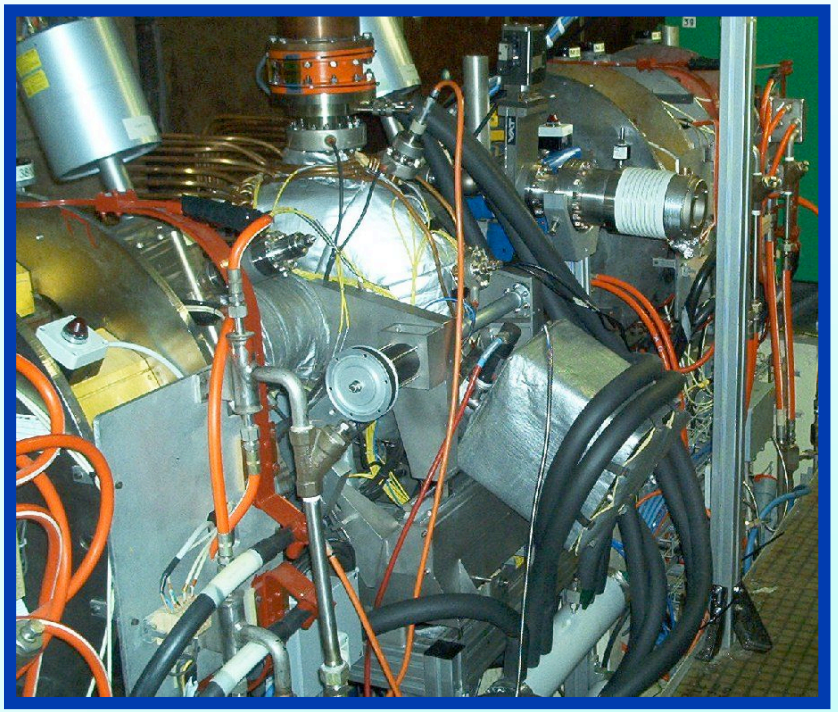


Overview /Power Plant / Status / Summary

- **ELETTRA is the Italian third generation light source in operation since October 1993 in Trieste.**
- The machine operates roughly 6500 hours/year, providing more than 5000 hours of light to the users.
- Operating modes:
  - Injection energy **0.9 GeV (linac injector)**
  - Multibunch (90% contiguous): **2 GeV, 330 mA**
  - Multibunch (90% contiguous): **2.4 GeV, 150 mA**
  - 4 bunches: **2 GeV, 40 mA**
  - SR FEL: **0.75-0.9 GeV, 40 mA (4 bunches)**
- New Major upgrades of the laboratory:
  - Replacement of the linac with a full energy **booster** injector
  - **FERMI**, FEL facility based on the upgrade of the existing linac
- Major upgrades of the storage ring:
  - RF Upgrade
  - Global Orbit Feedback
  - ……

Overview /Power Plant / Status / Summary

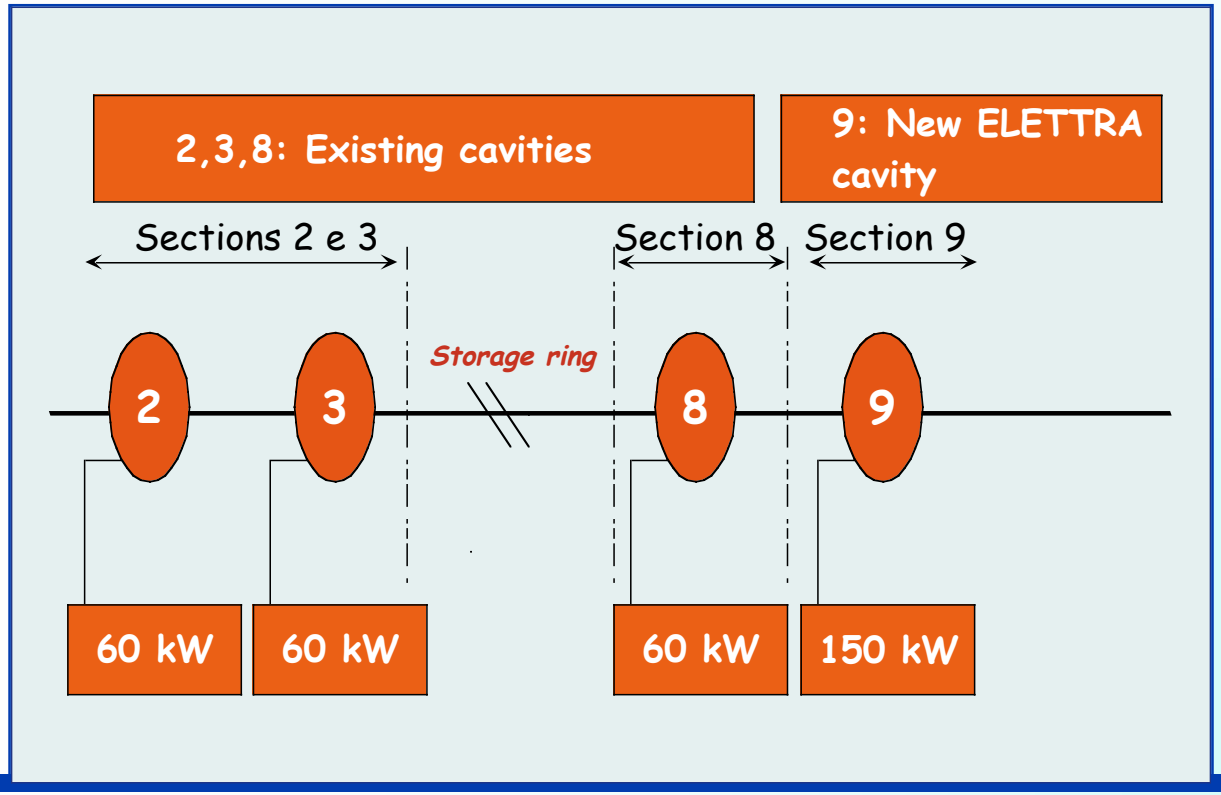
- The RF system did not have any major upgrade from its installation in 1993.
- It was designed for 400 mA, 1.5 GeV.
- It is composed of four 500 MHz 60 kW plants, using a UHF TV klystron as the main amplifying stage.
- Each plant feeds an ELETTRA type cavity.
- The requirements of RF power have greatly increased with the number of installed insertion devices.



- **TARGET OF THE PROJECT**
  - Provide the RF system with the necessary **operating margins**, when all IDs are operational (with a slight improvement also in beam lifetime).
  - Increase available RF power in view of possible increase of beam current and energy.

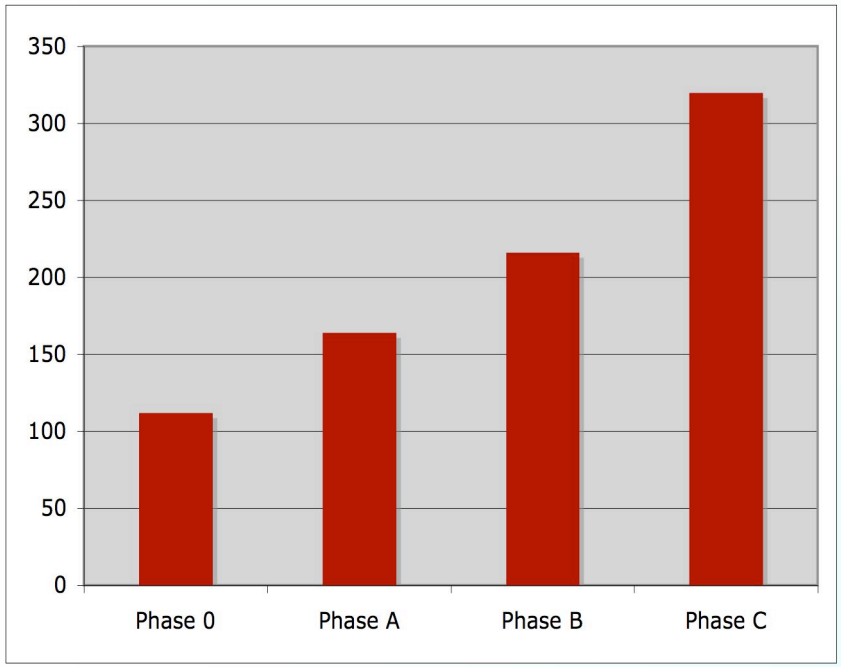
- **DESIGN STRATEGY**
  - **Minimum interference** with machine operation.
    - Gradual approach.
    - No increase of the space for RF components in the machine.
      - Same number of cavities.
      - No sc cavities.
  - **Consistency** with other upgrades of the facility.
  - **Take benefit of working in the UHF band.**
    - Use as much as possible solutions adopted in broadcast applications.

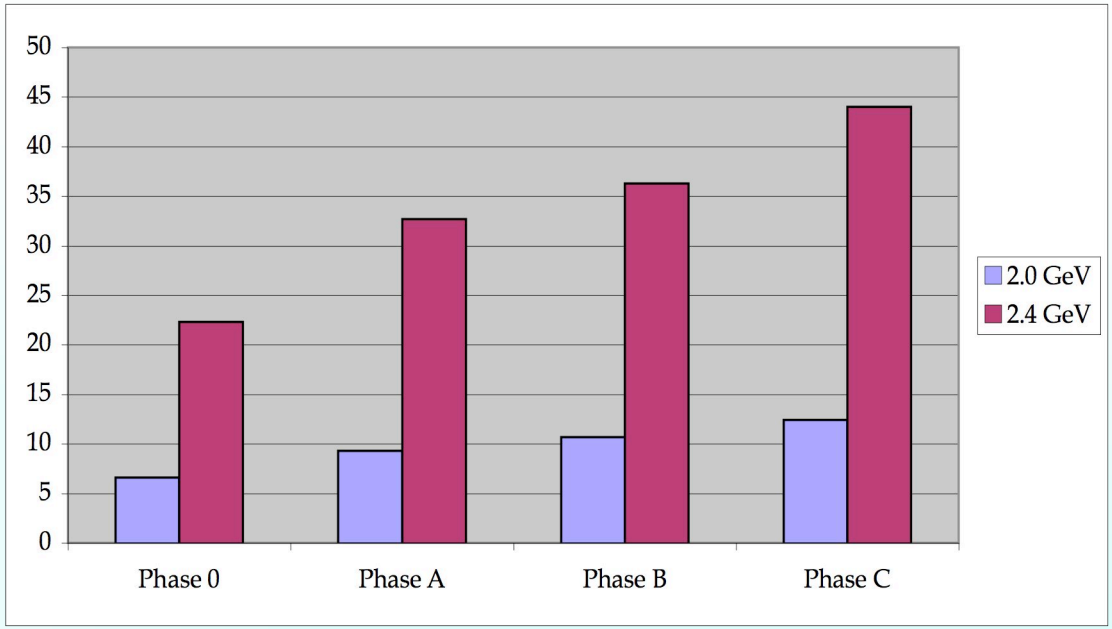
- **MULTI-STAGE APPROACH**
  - **PHASE A:** upgrade one 60 kW plant to 150 kW
  - **PHASE B:** repeat phase A on another plant
  - **PHASE C:** upgrade the two remaining plants in the same way
  - At the end of phase C, the available RF power will be **600 kW**.



PHASE A IS NOW IN THE CONSTRUCTION PHASE

Overview /Power Plant / Status / Summary



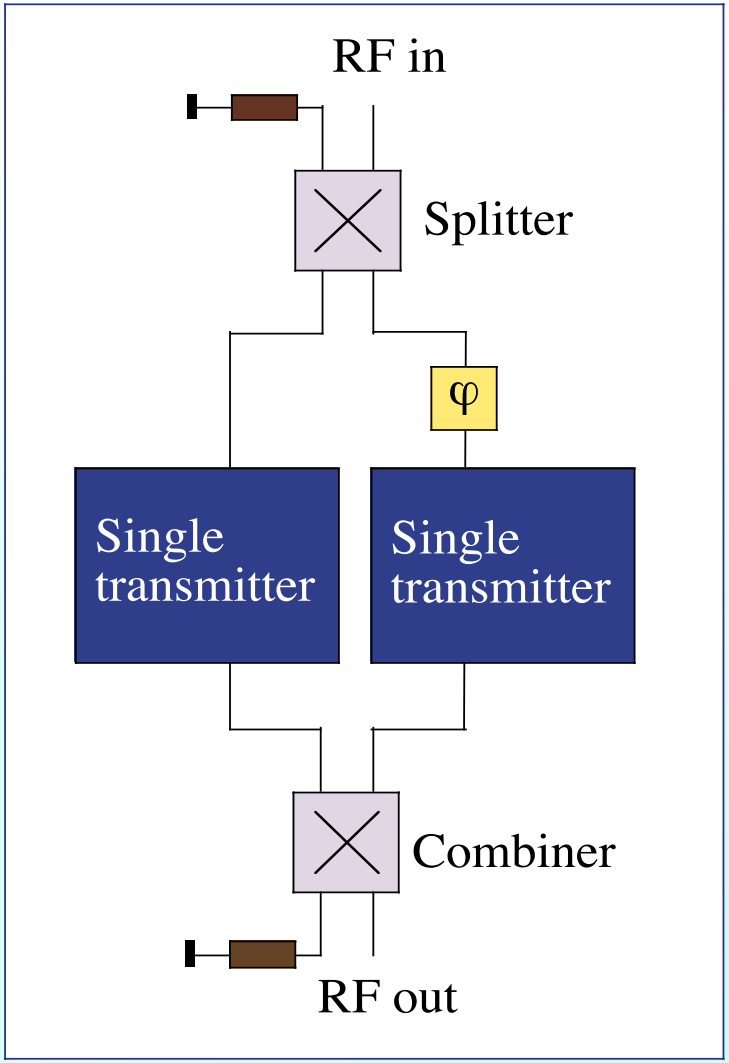


- Available beam power (in kW)

- Touschek lifetime (hours) at the usual currents and energies (3HC not taken into account).

Power Plant : Amplifier / Power Transmission / Layout

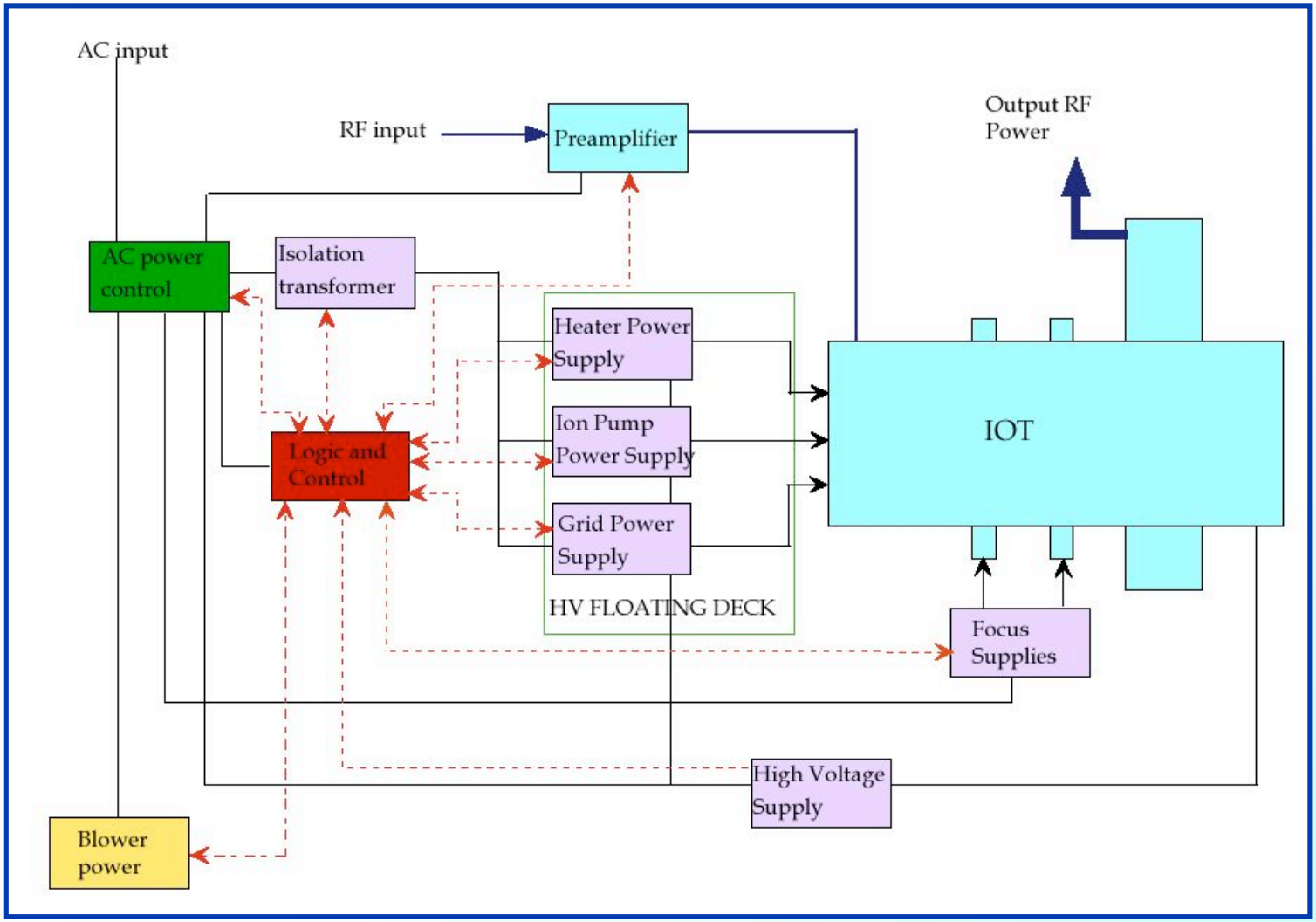
- The Power Amplifier will be made **combining two 80 kW** transmitters providing 150 kW at the amplifier output.
- The final stage of each transmitter will be a 80 kW IOT.
- The output of the two transmitters will be combined by means of a **switchless combiner.**
- **Each transmitter will be completely independent to allow standalone operation, thus increasing operational flexibility.** The fault or the maintenance of one transmitter does not imply the interruption of the operation of the plant, since the other transmitter continues to operate.
- It has been acquired as a **turn-key system from industry (ELECTROSYS, Orvieto Italy).**



Power Plant : Amplifier / Power Transmission / Layout

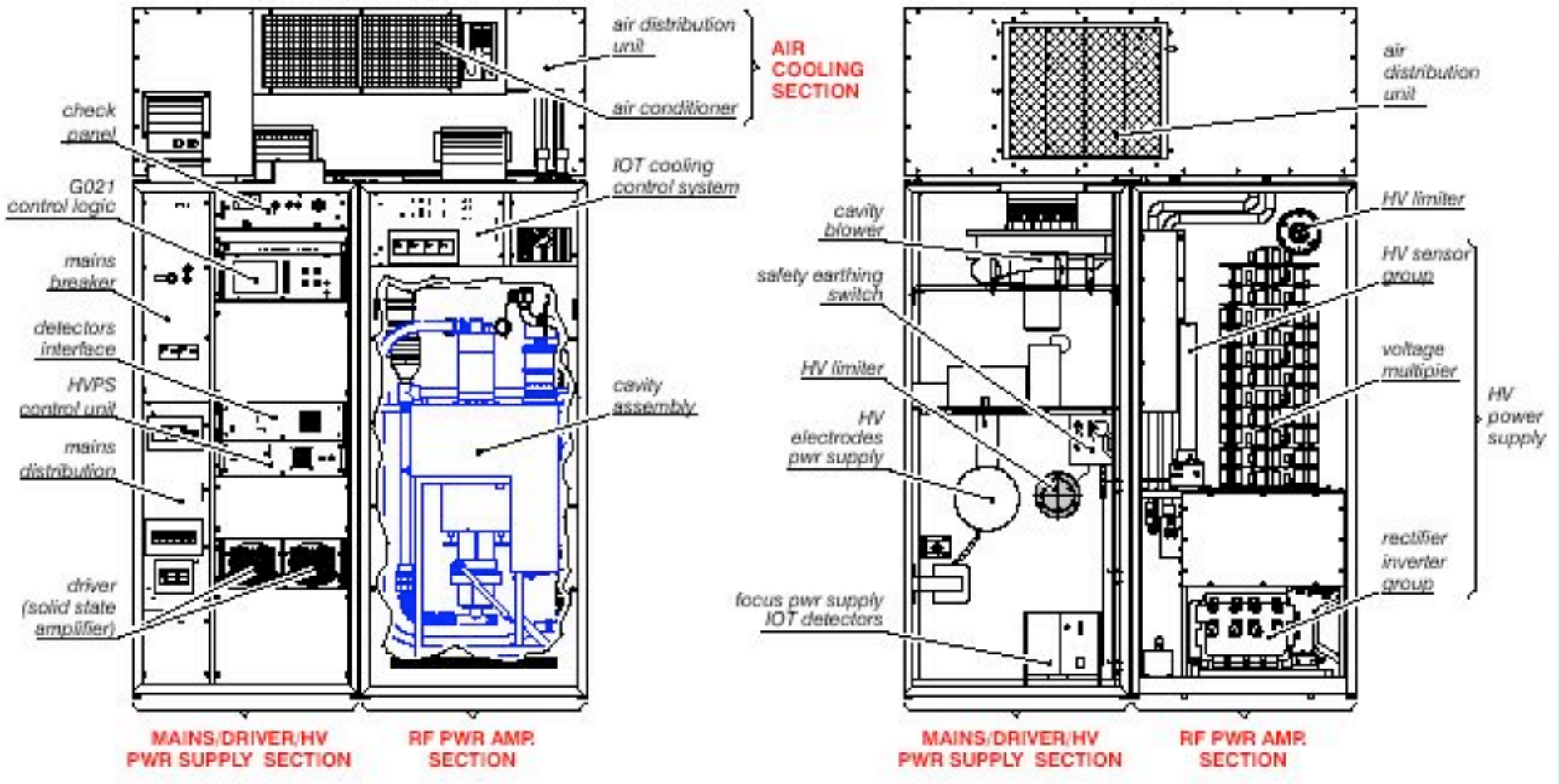
Power Amplifier - Abridged specifications	
Operating frequency	499.654 MHz
Bandwidth (-1dB)	± 1 MHz
Output power higher than	150 kW cw
Input power	13 dBm
Max. admissible VSWR(all phases)	1.3
Output power dynamics	> 35 dB
Harmonic content at output power	< - 30 dBc
Spurious and sidebands levels in ± 20 MHz	< -60 dBc
Signal to noise ratio within bandwidth	better than 70 dBc
Efficiency at full output power	> 65 %
Maximum RF phase variation vs. output power for full drive modulation	30 ° overall
Power stability	± 1% at each output level
Phase stability	± 0.5 ° at each output level

Power Plant : Amplifier / Power Transmission / Layout



Single transmitter block diagram

Power Plant : Amplifier / Power Transmission / Layout



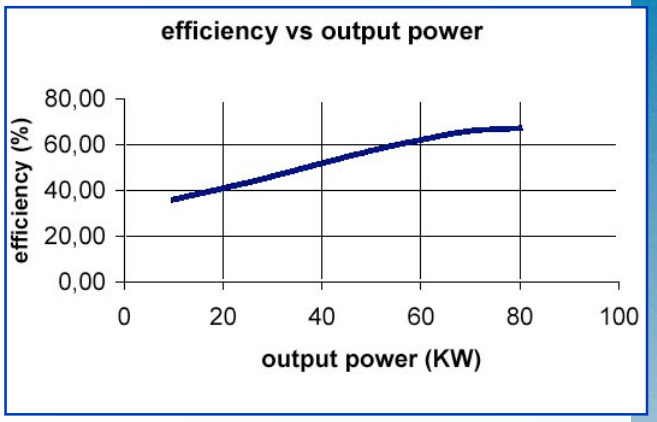
Courtesy of Electrosys

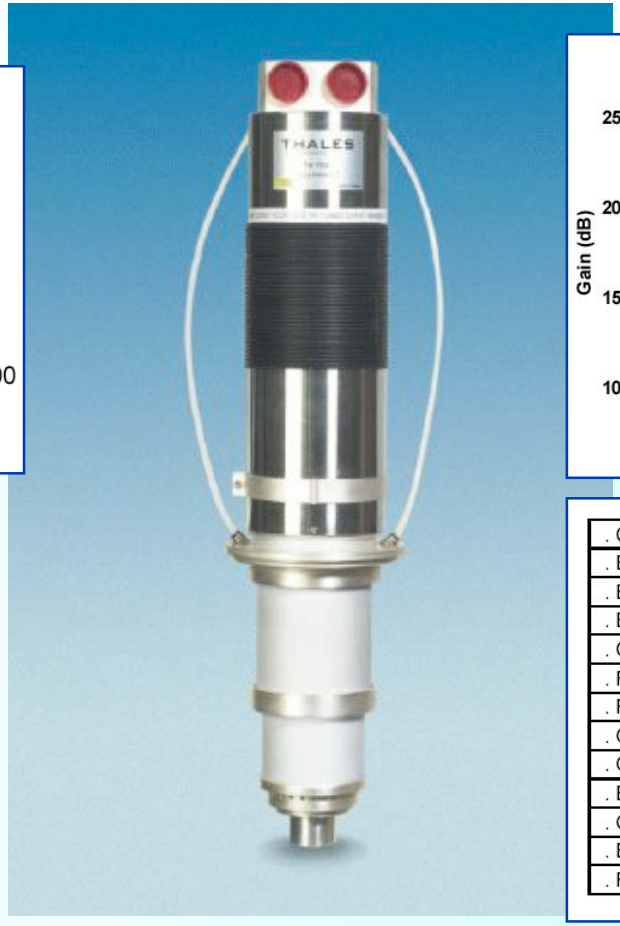
Power Plant : Amplifier / Power Transmission / Layout

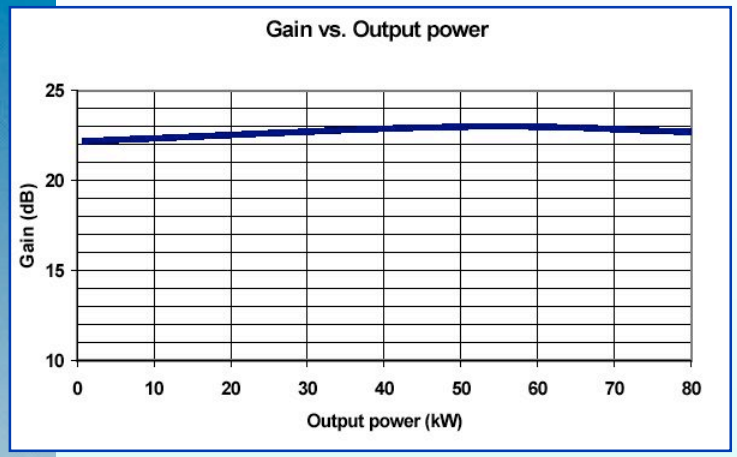
Pictures taken at Electrosys

Power Plant : Amplifier / Power Transmission / Layout

- The tube adopted is Thales TH 793.
- The use of other tubes assemblies could eventually be possible by use of a replacement kit.







. C.W. output power	80 kW
. Beam voltage	36 kV
. Beam current	3.3 A
. Body current	50 mA
. Quiescent beam current	0.15 A
. Filament current	24 A
. Focusing current	18 A
. Grid voltage	- 95 V
. Grid current	-60mA
. Efficiency	67 %
. Gain	22.7 dB
. Bandwidth at - 1 dB	6.5 MHz
. Frequency	500 MHz

Courtesy of
THALES ELECTRON DEVICES

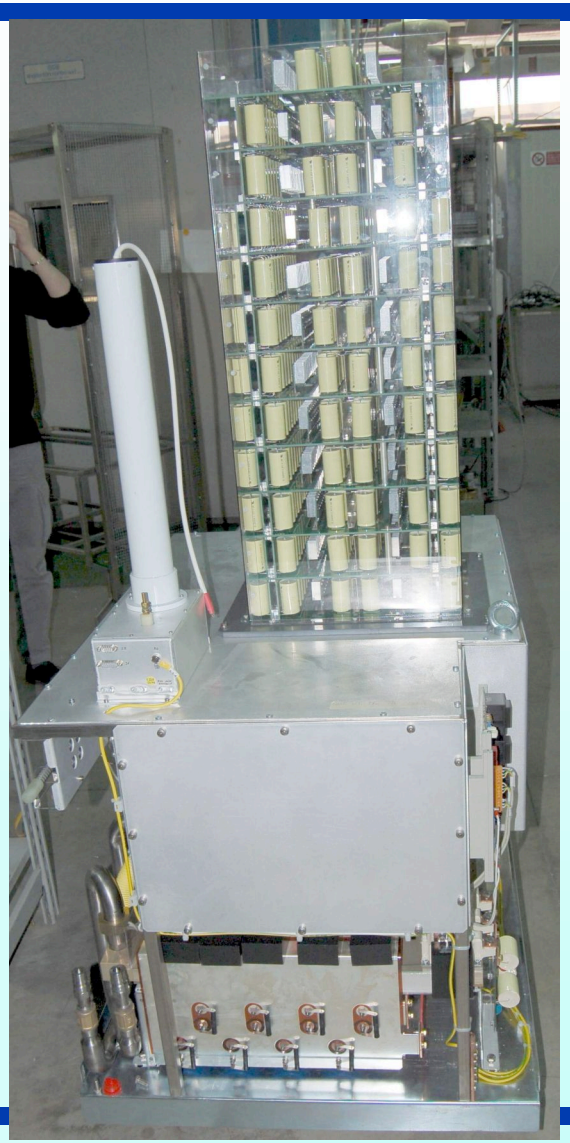
IOT POWER SUPPLIES

- The specifications allow for some redundancy to take some margins in case of different tubes

Typical specifications for one tube	
Power	80 kW
High Voltage Supply	37 kV, 3.8 A
Heater Supply	12 V, 40 A
Ion Pump supply	4 kV, 3 mA
Grid supply	-150 V, ± 130 mA
Focus Supply	12 V, 30 A

Power Plant : Amplifier / Power Transmission / Layout

- **The HV power supply of each IOT will be a switched mode power supply.**
  - The structure is **more compact**.
  - Lower residual ripple.
  - Beam voltage is stabilised independently of:
    - Output power variations.
    - Mains input variations
  - If needed, **switching frequency can be adjusted** in the range 16 to 21 kHz.
  - No oil capacitors or transformers are used.
  - No crowbar tube.



Power Plant : Amplifier / Power Transmission / Layout

- **SWITCHLESS COMBINER**
  - Four ports device made up from two hybrids and a variable phase shifter.
  - Depending on the phase shifter position one has four modes of operation.

  - Advantages:
    - 3 dB power loss when one transmitter is out of service
    - Maintenance of one transmitter can be made while the other is in service
    - Hot adjustment is possible
  - Disadvantages:
    - Dimensions

Pictures taken at Electrosys

Power Plant : Amplifier / Power Transmission / Layout

Pictures taken at Electrosys

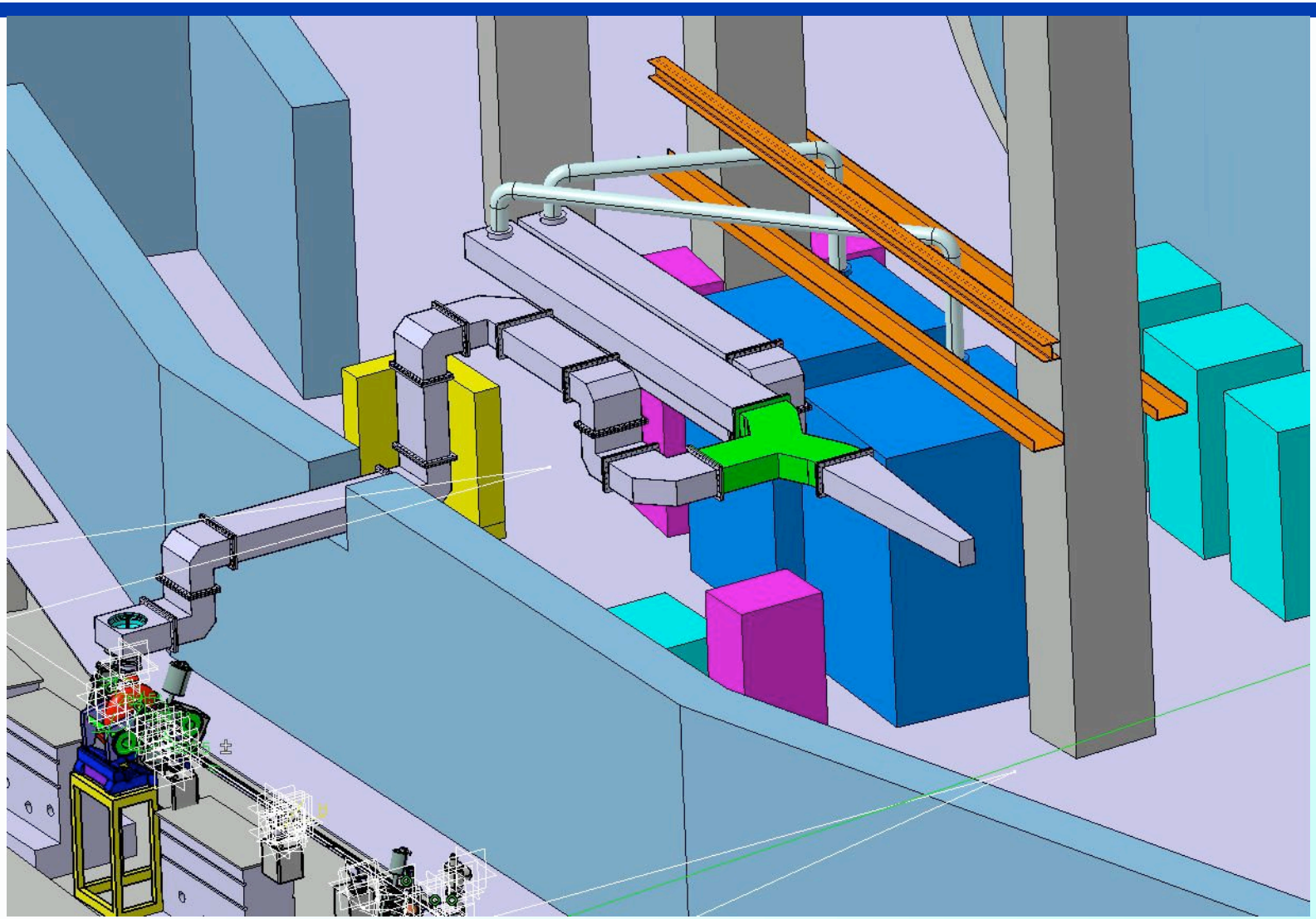
Power Plant : Amplifier / Power Transmission / Layout

Pictures taken at Electrosys

Power Plant : Amplifier/ Power Transmission / Layout

- The power amplifier will be protected by a 200 kW 500 MHz circulator, which has been ordered to AFT (Germany)
- Power transmission will be done with WR1800 waveguides. The waveguide components have been ordered to MEGA Industries (USA)

Power Plant : Amplifier/ Power Transmission / Layout



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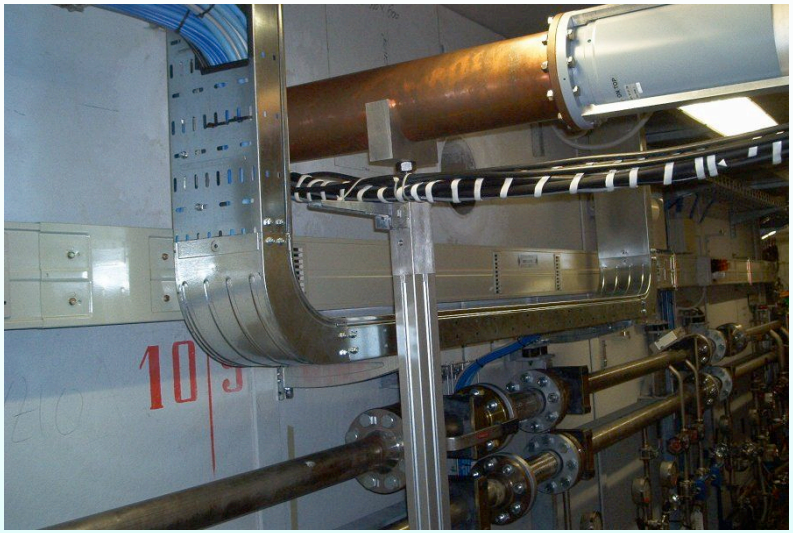
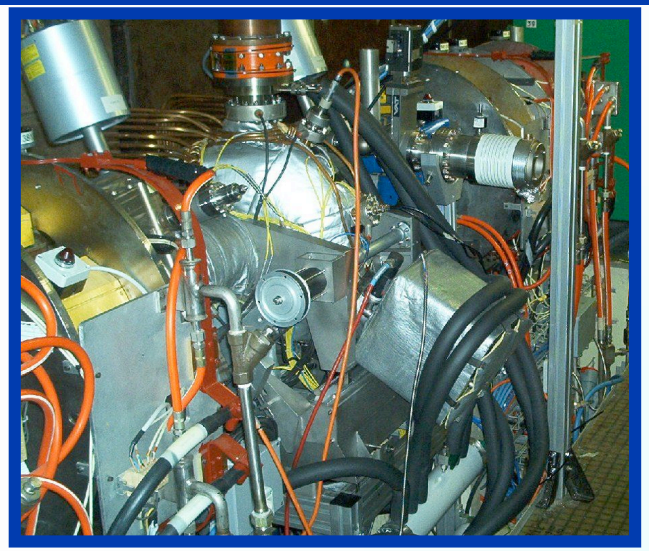
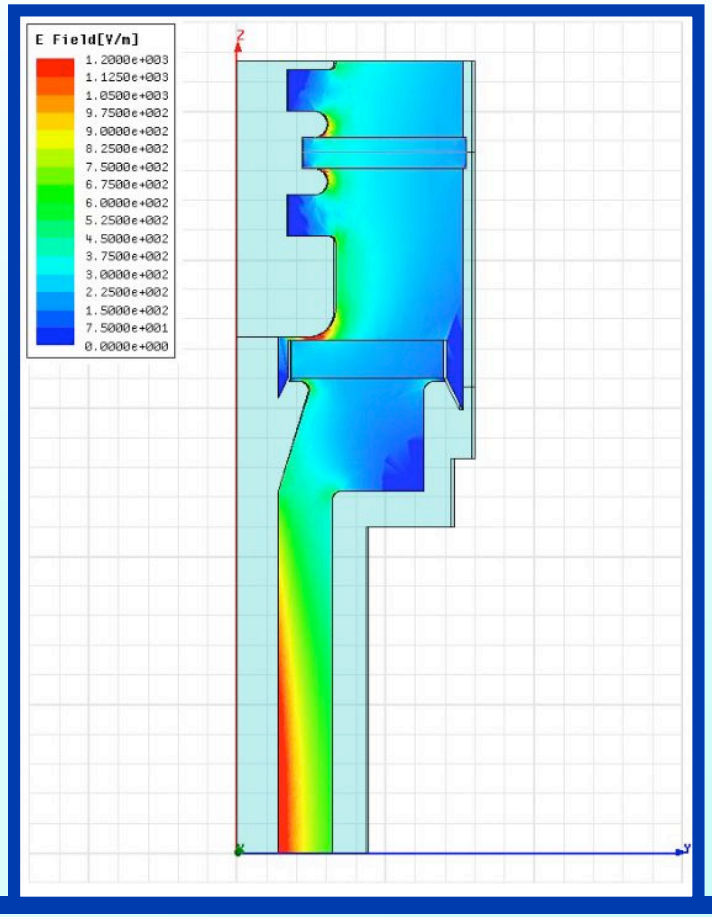




- The new cavity was installed in section 9 in **November 2003**. It is similar to the ones provided to SLS and ANKA (upgraded cooling efficiency).



- In parallel a design study is in course to improve the performances of the power coupler both at fundamental and HOM frequencies.
- This includes:
  - Design of a **new coaxial transition element** (airside) integrated with the **coaxial to waveguide transition.**
  - Installation of **diagnostic devices** in the coaxial element.

- **Components**
  - Amplifier:
    - Factory acceptance test to be completed next week.
    - Afterwards delivered to Trieste.
  - Power Transmission:
    - Circulator to be delivered these days.
    - Waveguides to be delivered first half of June.
- **Installations**
  - Installations have to fit in the planned shutdown, therefore they should be well organised.
  - Program of activities:
    - Summer shutdown (from end May to half July 2006): amplifier and circulator installation.
    - End July to October 2006: plant commissioning on dummy load.
    - October' s shutdown (3 weeks): connection to the cavity.
    - November-December 2006: new plant commissioning.
    - January 2007: start dismounting old 60 kW plant.

- **The first phase (phase A) of the ELETTRA RF Upgrade is under construction.**
- A multi stage approach was chosen to minimise interference.
- Most of the components take benefit of existing products in UHF broadcast market and are supplied by industries.
- The completion of phase A is foreseen by the end of this year.
- This phase will provide a certain amount of safety margin to the system and provide the booster power plant (to be installed in 2007).
- Based on the results and on the development activities of the lab, a decision on the timing of the remaining phases will be taken.

➢ACKNOWLEDGEMENTS

➢Many thanks to:

- ➢G. Ocera from ELECTROSYS and his staff.
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