- ESRF RF is Derived from LEP - CERN
- Frequency 352.2 MHz
- 3 High RF power units of 1MW
Initial Radio Frequency set-up for the Storage Ring

- **Cavity#1**
  - HVPS 100kV-22A
  - KLYSTRON
  - 1MW RF

- **Cavity#2**
  - 5MV - 500kW

- **Cavity#3**
  - HVPS 100kV-22A
  - KLYSTRON
  - 1MW RF

- **Cavity#4**
  - 5MV - 500kW

**Wave-guide Bypass**
The only redundancy we had.
(Switching = 4 hours)

**TRANS#1**

**TRANS#2**

Cavity Test Stand

Dummy Load
Limitation of the TURNKEY solution

The original set-up was based on a turnkey transmitter made by Industry

This solution was chosen because:
- Staff was not yet complete.
- No infrastructure at E.S.R.F.
- Know how available from Industry.

This was a good and reliable choice for a tight construction planning.

This worked fine for 7 years but we had problems of:
- Spare parts (the supplier went to bank route).
- Integration within the E.S.R.F control standards.
- Limitation for testing and in the choice of operation
3rd Radio Frequency Transmitter and RF general upgrade

- Increase power margin @ 200mA (Decrease the RF power per cavity window).
- Increase accelerating voltage over 10MVolt.
- Object oriented design to get a high modularity.
- Control software and VME support from ESRF computing service.
- Cavity 5 and 6 can be run in passive mode when less power is needed or for testing on Dummy load.
- Fast switching in testing mode. (a couple of minutes).

This new RF module has been operational end of 1997.
Upgraded Radio Frequency set-up

Cavity#1  Cavity#2  Cavity#3  Cavity#4

5MV - 500kW

To Booster Cavities

HVPS 100kV-22A  KLYSTRON  TRANS#1 1.3MW RF

Dummy Load

HVPS 100kV-22A  KLYSTRON  TRANS#2 1.3MW RF

Cavity Test Stand

Dummy Load
Where do we stand?

⇒ 10 years operation.

⇒ > 7 years of User service (5500h/year).

⇒ The RF represents about 25% of the machine downtime.
RF contribution to the USM time loss

- Cavity window failures.
- Crowbar due to klystron.
- Current ramped from 100 to 165mA.

Year (Scheduled USM time)

% of Time lost due to all failures
% of Time lost due to RF
RF and Machine “engineer” MTBF

Year


Machine MTBF
RF MTBF

MTBF(hour)

0 20 40 60 80 100 120

SR-RF3 started
RF upgrade in Parallel to USM

Machine trips
1994: 13
1995: 15
1996: 27
1997: 20
1998: 20
1999: 22
2000: 28
2001: 30

RF trips
1994: 40
1995: 41
1996: 87
1997: 44
1998: 46
1999: 54
2000: 71
2001: 102

Machine trips 2000: 199
2001: 176
Difference: -23

RF trips 2000: 76
2001: 52
Difference: -24

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FULL POWER / HALF POWER - AUXILIARIES IMPACT

⇒ Auxiliaries - Many youth troubles such as:
- Small DC power supply.
- Panel display giving interlock.
- Ion pump HV transformer.
- Master source.

⇒ Klystron - 5 @ 500kW and 9 @ 1MW (Several trips due to a turbulent klystron).

⇒ Arcs are a significant part of the RF trips.

⇒ Control - Problem of VME.

⇒ Crowbar is very quiet: 0 crowbar over 2 years.

RF trips over the 2 last years.
(normalized with running hours)
50 arc detectors are installed on Storage Ring RF transmitters. Total response time (between detection → No RF) is 5µSec.

Arc detection trip participation
- **2000**: 51% of RF trips, 20% of Machine trips.
- **2001**: 43% 13%

June 2000: Modification of electronic design of cavity window detectors. Removed flip-flop and added noise filtering @ 500nSec.

August 2001: Extension of modification to all detectors with noise filtering @ 100nSec.
KLYSTRONS END OF LIFE

⇒ Average lifetime = 16000 hours.

⇒ 6 klystrons failures over 10 years.

⇒ No correlation between failures and operation at full power. ONLY ONE KLYSTRON DEATH AT FULL POWER.

⇒ The klystron **H.V Gun** is the dominant problem.

A statistic done at LEP over 44 transmitters showed that 61% of the klystron failures were due to the gun.
KEY ISSUES

⇒ The hardware implementation is a dominant factor.
   - **Electro Magnetic Immunity** must be seriously considered
     (Grounding of cubicles and racks, short wire, shielding …).
   - Good protections: in case of problem, particularly with high power,
     it is very important to act very fast on the equipment (crowbar, arc detectors).

⇒ **Protection**: A good compromise between a fast interlock protection
   and a good RF equipment stability is a key issue.

⇒ **Component over-dimensioning** is beneficial to the reliability of
   the equipment. This was applied with success to the HVPS and the
   HV interface.
CONCLUSION

For the next years we hope to double the RF MTBF and reach 200 hours.

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