OPERATION OF SYNCHROTRON RADIATION SOURCES

Quality of the photon beam
Training of operators:
Their role and their contribution.

J-C.BESSON, J-F.LAMARRE, A.NADJI.

LURE, Orsay (France)

Laboratoire pour l'**U**tilisation du **R**ayonnement **E**lectromagnétique

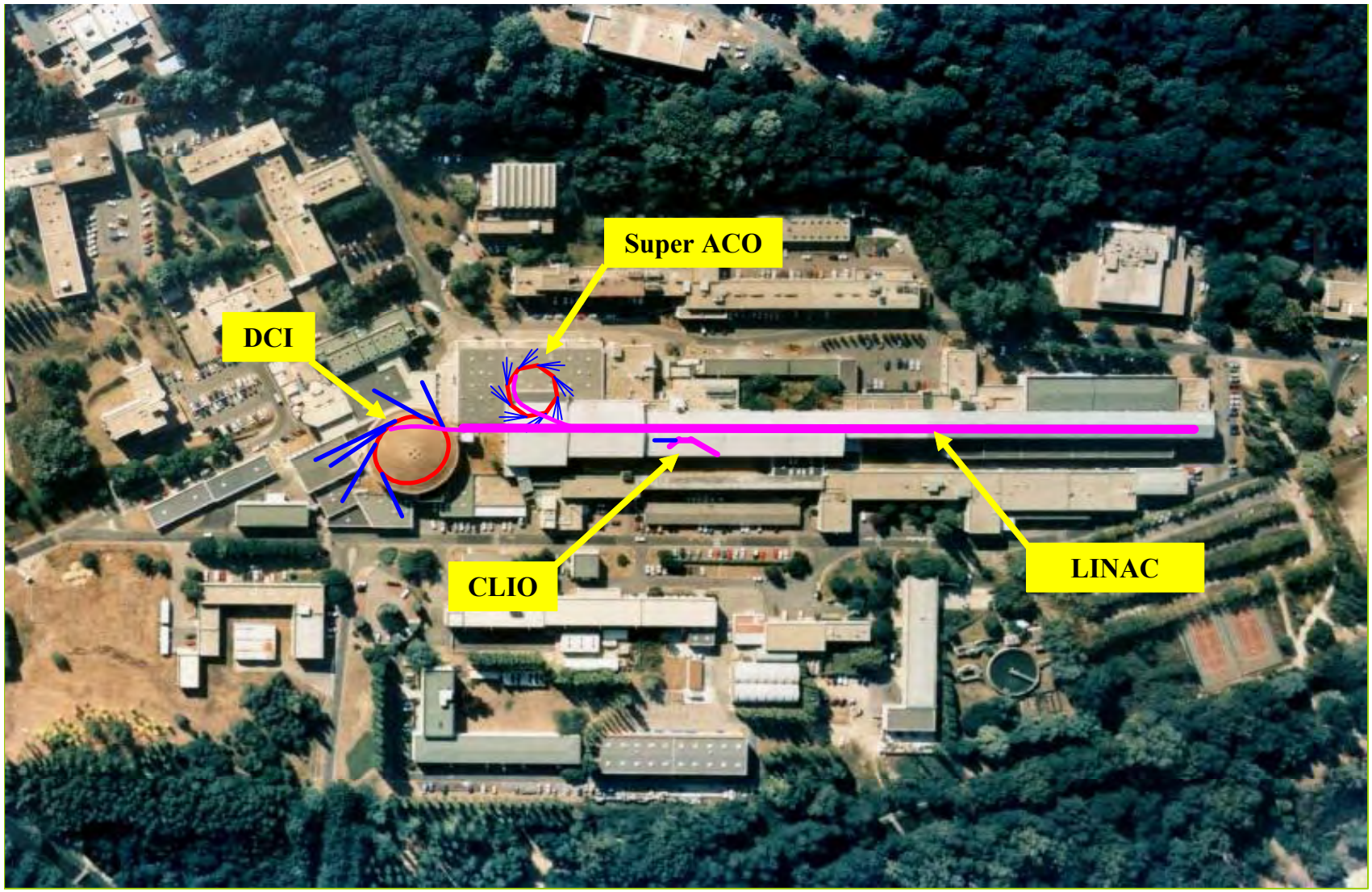
- **DCI** : Storage ring of 1.85 GeV,
  produces photons in the X-rays range. Circumference 92m,
  in operation since 1975.

- **Super ACO** : Storage ring of 800 MeV,
  produces photons in the V.U.V range. Circumference 72m,
  in operation since 1987.

- **LINAC** : 1.1 GeV (e^+) Linear Accelerator.
  Injector of both DCI and Super-ACO. In operation since 1955.

- **CLIO** : Infrared free electron laser on 50 MeV linac.
  In operation since 1992.

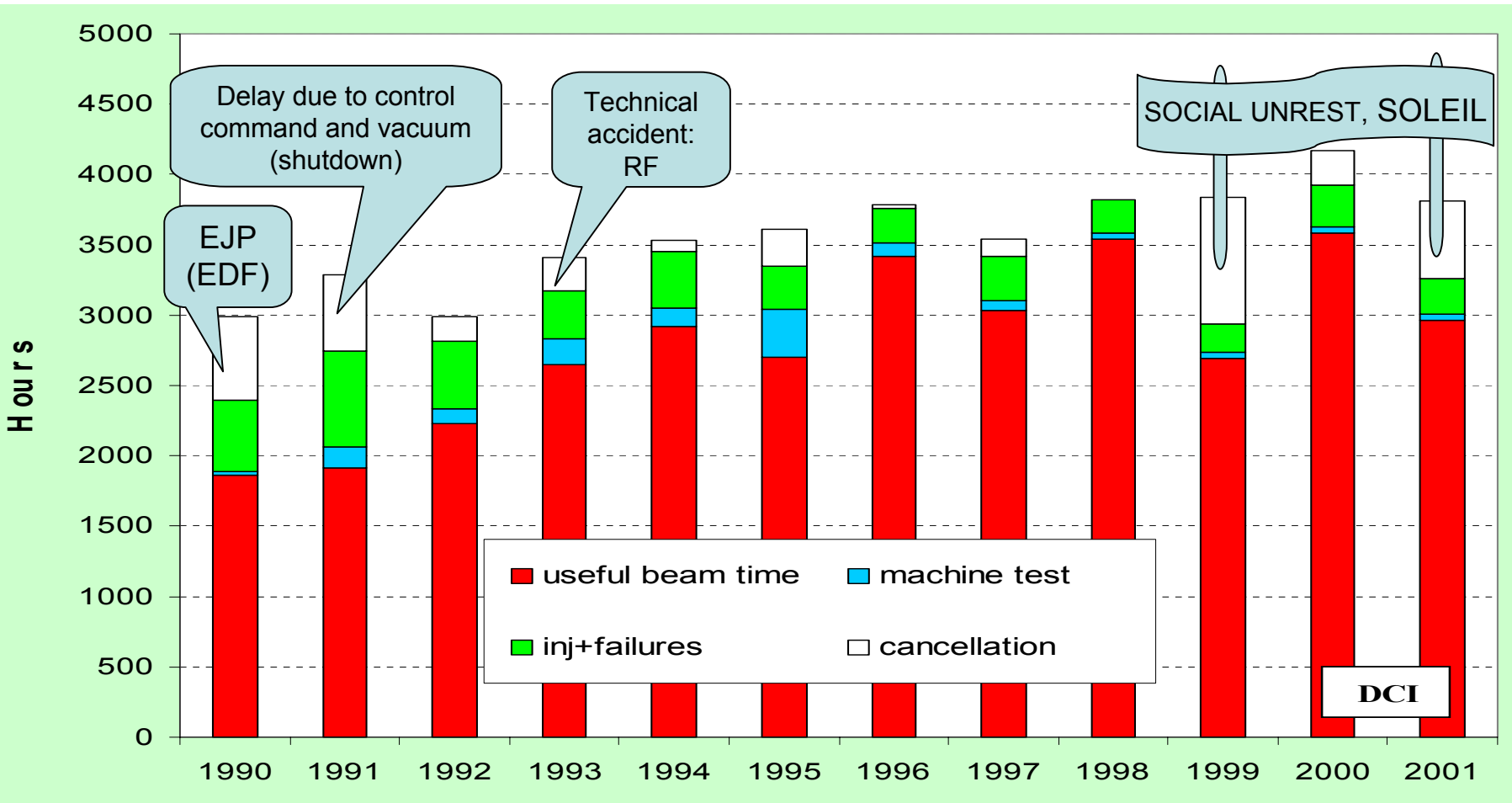
Air sight of the site



- First, I choose to present quickly the result on the first machine of LURE, DCI.
- DCI is a first generation machine with always a good reliability.
- Super ACO presents about the same performances.

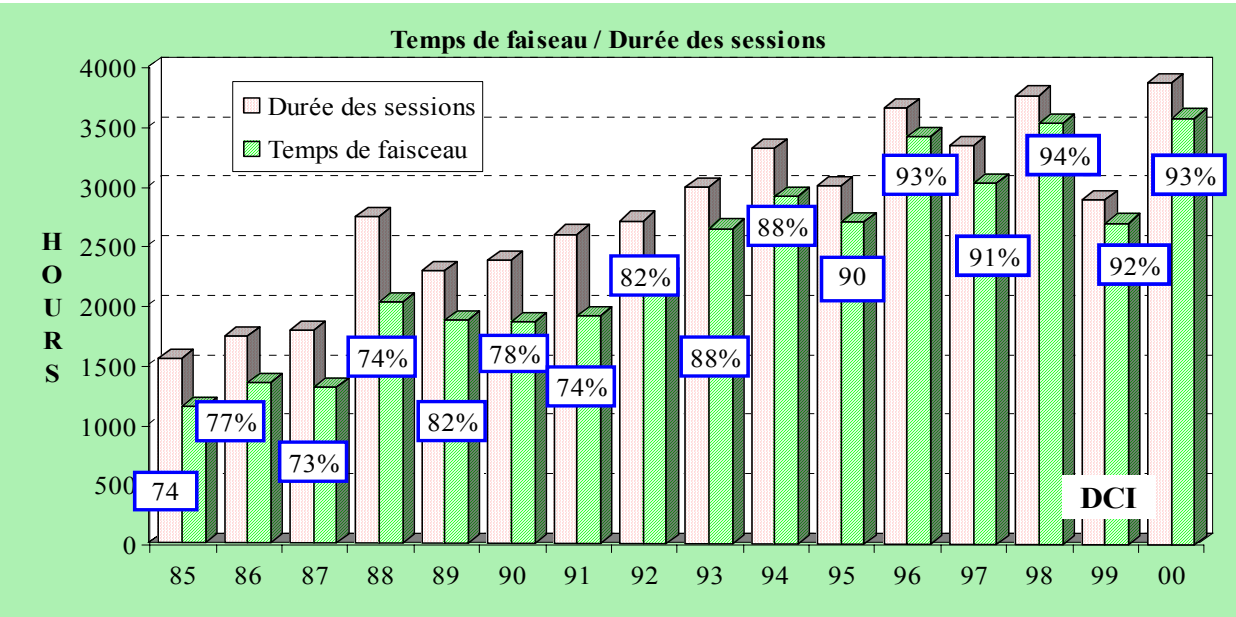
Beam Time (DCI)

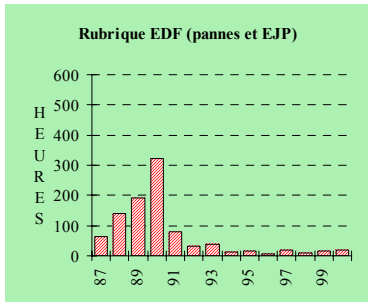
Difference between effective and scheduled working time.
The difference is not only due to machine failures.

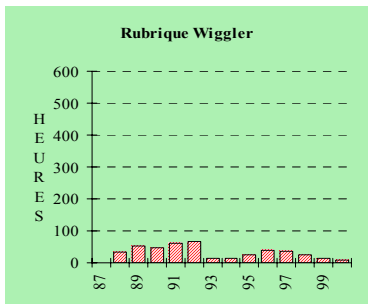


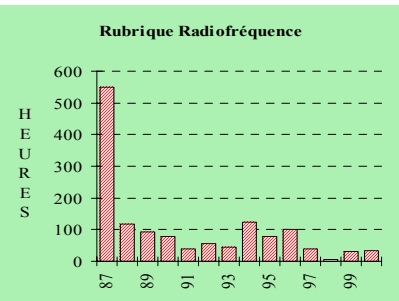
DCI Performance during operation

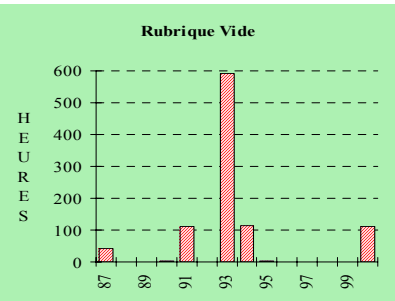
The following analysis takes into account only the effective time of operation which is comprised between 3000 and 4000 hours (historically, LURE doesn't work during the week-end).

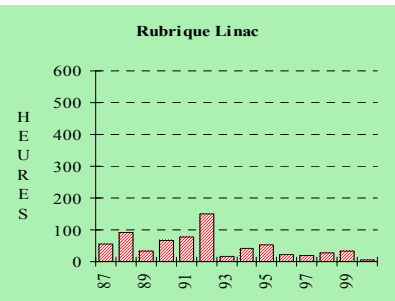


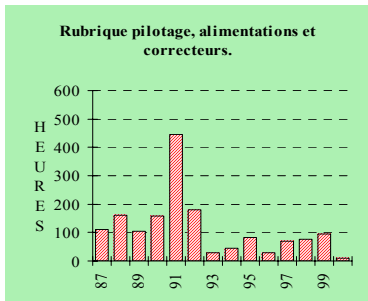






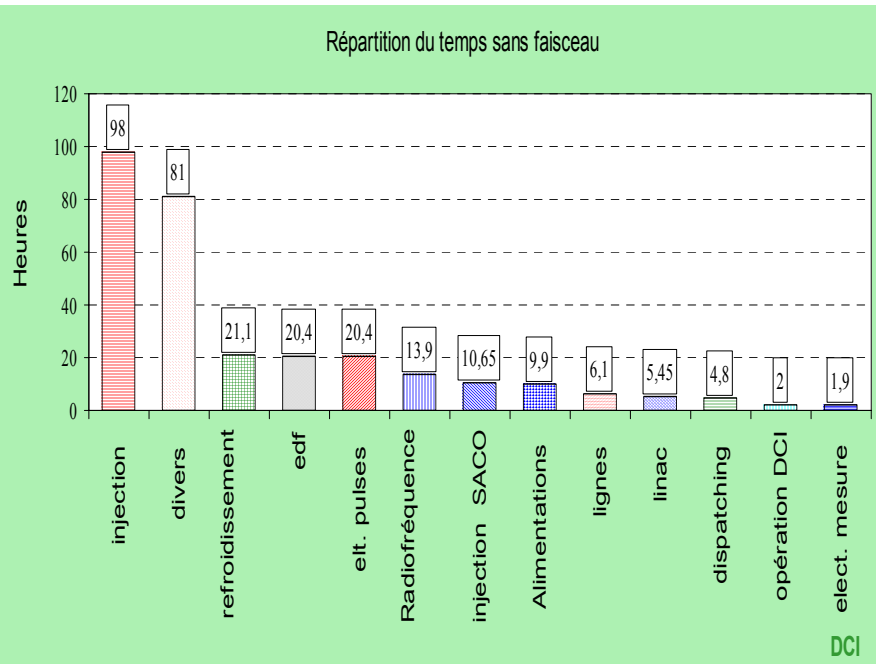


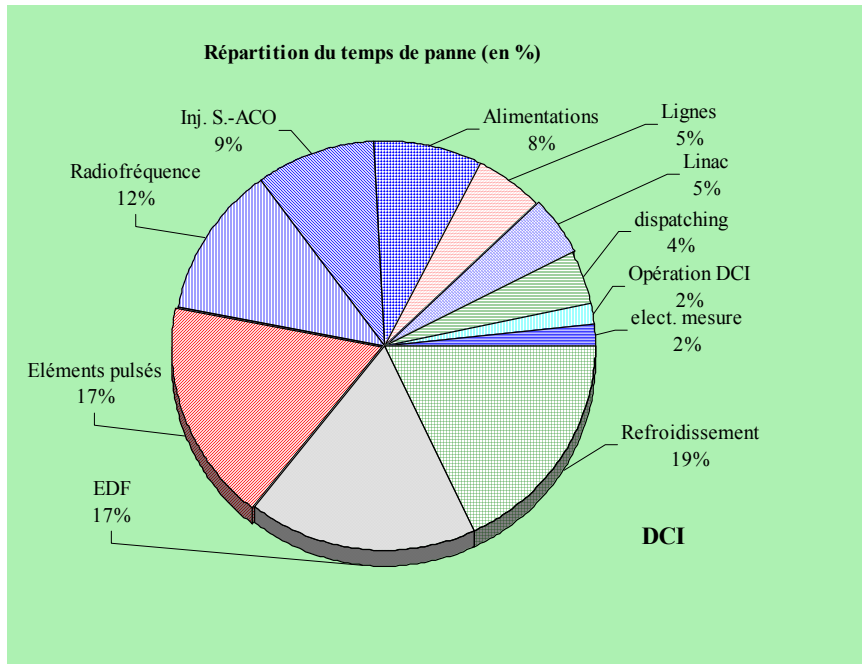




DCI Performance in 2000

- This analysis is carried out using 3875 hours of operation.
- The effect beam time represents 92.4% of the total operation time. Among the 295 hours without beam, we can see 98 hours for the injection (energy ramping of the machine and the wiggler) and 117 hours of failures. This distribution is shown below.
- The duration of failures represents only 3% of the total operation time.





Photons quality ?

The analysis of the results show that the machines are reliable.

- Hardware and software have stood up long duration tests.

- Improving further the efficiency is very difficult. One has to develop a common instrumentation between machine and beamlines. More direct and better structured relationship between users and control room.

Efficiency / beam quality

- The mere presence of the beam in the storage ring is not sufficient to validate a good operation of the machine.
- The beam has to be well used and to correspond to the users requirements.
- The operator has to be able to ensure a good quality of the beam during the shift.

The role of the operator

- The basic role of the operator is to install the beam and to control it.
- To carry out the diagnostics of the incidents. A good operator doesn't wake up the technical people unless necessary and can restart good conditions as soon as possible.
- He participates to the machine studies and to the commissioning of the different optics.
- Being the only person usually in the control room, he is the best interlocutor to the users and to the machine physicists.

The role of a good operator

- A good operator should be motivated not only to operate the installation under his responsibility but also to improve the facility's operation.
- In addition to "ordinary knowledge" in physics, electronics and computer science, a standard technician, after school completion must study and gain experience about physics and operation of storage rings. He has to describe as exactly as possible observed phenomena which may be complicated, in order to give a correct interpretation of his observations.
- These observations may be of prime importance for machine physicists. Users will have competent partners even in absence of a machine physicist.
- **An operator is a "generalist" dealing with specialists.**

How to become a good operator?

A commonplace for you perhaps, but not for a newcomer.

<u>At the beginning</u>:

- Understand a specific and new vocabulary.
- To know as exactly as possible the total set of components of the facility and their location.

The training (1)

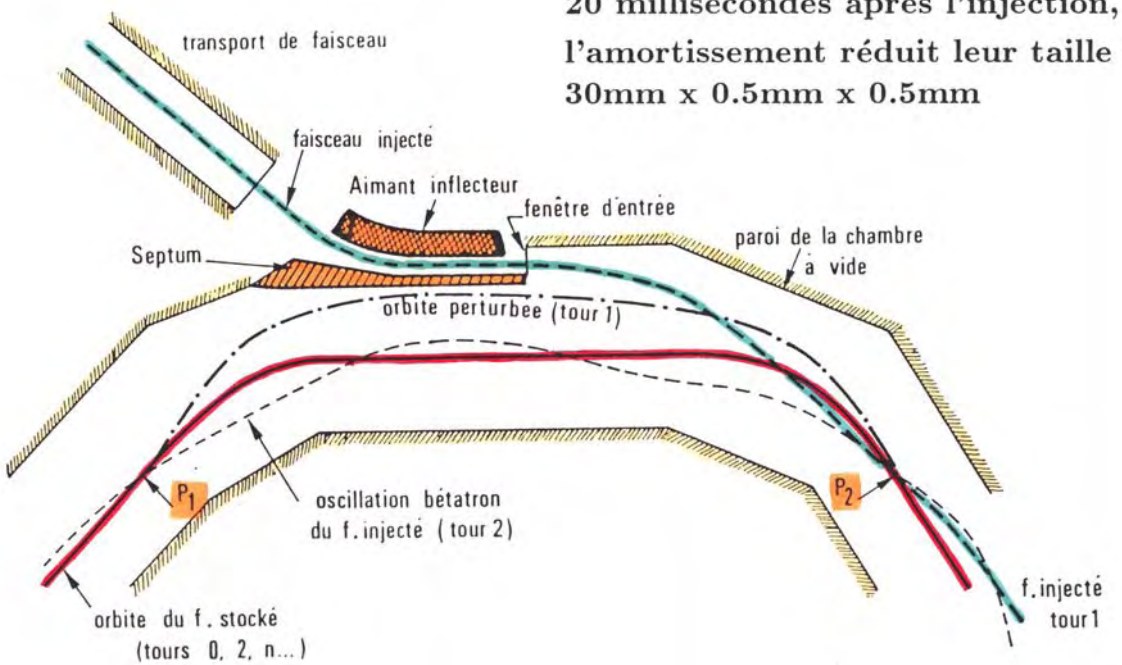
During the next period, once the various components are identified.

- One has to explain their role as simply as possible, avoiding a purely mathematical explanation. Huge equations are not desirable as they can conceal the physical facts and dissuade the operator to understand what is really going on.
- It is compulsory to define accurately the parameters of stored beams: beam energy, lifetime, tunes, orbit position, transverse beam dimensions, stability. One has to understand why these parameters are important and which components are involved in their variations.
- A set of simple but extensive documents (schematics) are generally helpful for further understanding.
- The use of modelisation programs is also very efficient, and helps to understand for example the action of a steerer on the beam and makes quite clear why a wrong setting of steerers distorts the orbit.

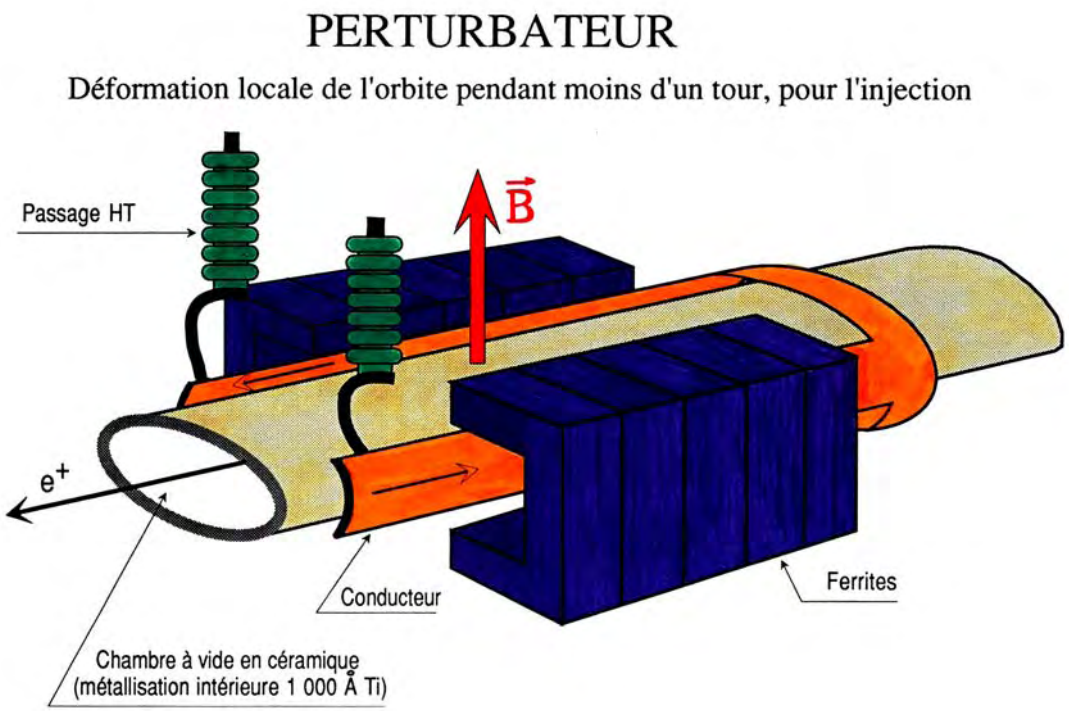
Training (Schematics: injection)

INJECTION et ACCUMULATION

Du Linac, 6.10^{+8} positrons arrivent par paquets de 7m x 5mm x 5mm.
20 millisecondes après l'injection, l'amortissement réduit leur taille à 30mm x 0.5mm x 0.5mm

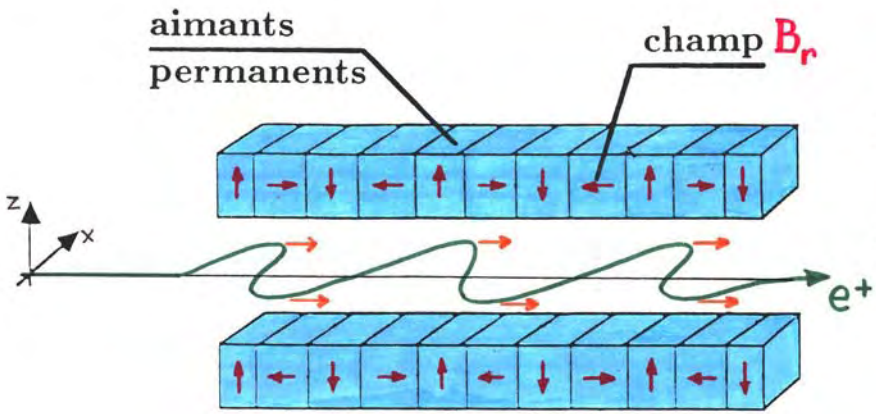


Training (Schematics: kicker)



Training (Schematics: undulator)

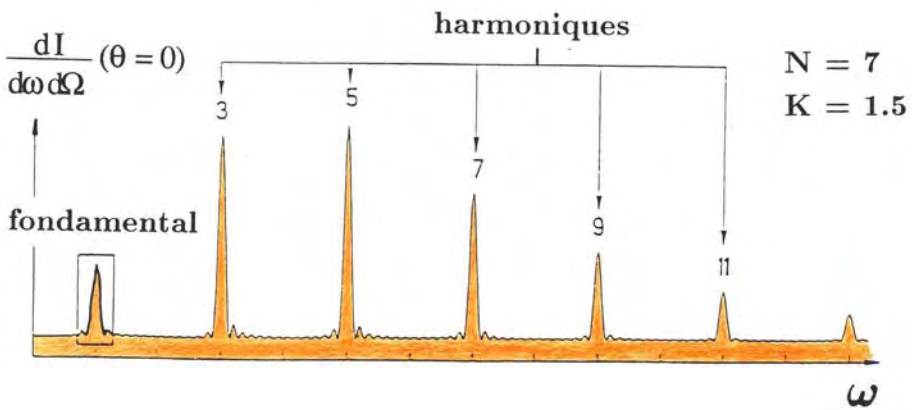
RAYONNEMENT SYNCHROTRON : ONDULEURS



Interférences constructives

Très faible angle d' émission

$$\alpha \frac{1}{E\sqrt{N}}$$



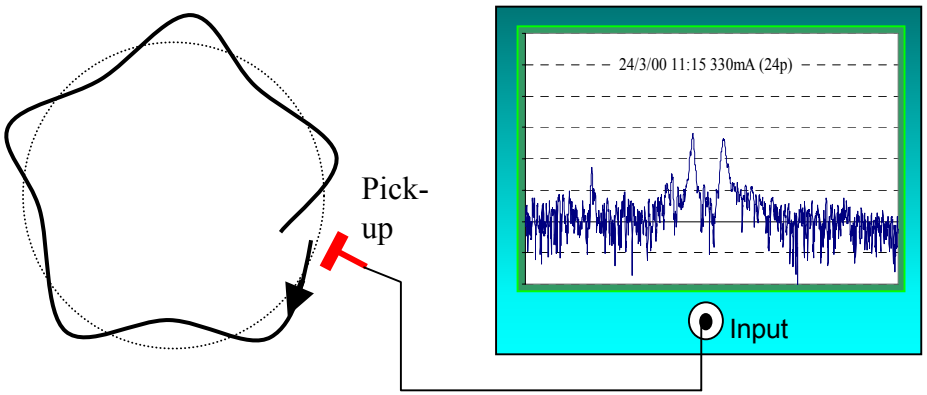
N = 7
K = 1.5

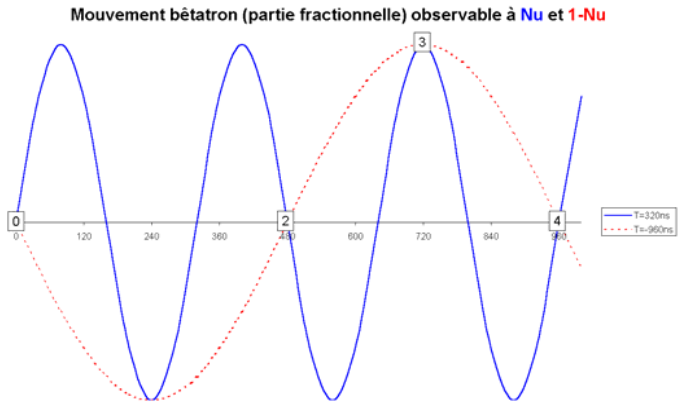
Spectre de raies
sur fond continu

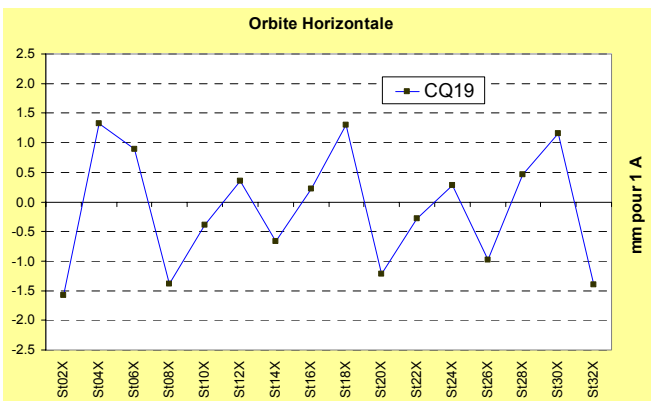
Training (Schematics: Betatron Tunes)

Fréquences observables à (ν : partie fractionnelle):

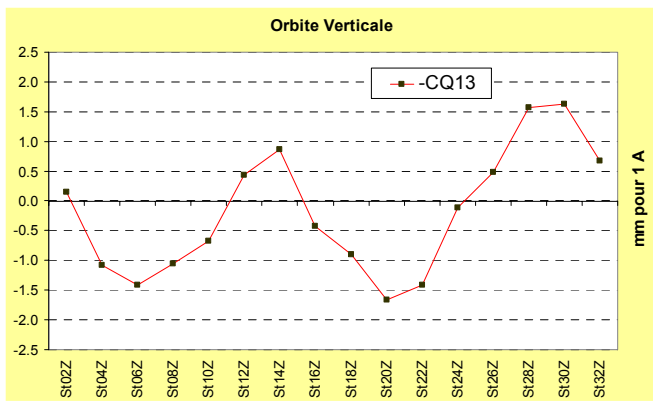
ν.frév, (1- ν). frév, (1+ ν). frév , (2- ν). frév, (2+ ν). frév ….







La variation de l'orbite fermée due à la variation d'un des correcteurs (vertical ou horizontal) de l'anneau est directement liée au nombre d'onde et permet de le visualiser (partie entière du nombre d'onde).



The training (2)

Don’t forget that the training is not the same for each operator, due to the following facts:

- The initial specialization may not be the same for all of them and the degree of abstraction required to understand complex phenomena also varies. The formation of operators should be an individual one.

- Each operator should be encouraged to have his own documents. They should be controlled in order to verify that there is no error included. This will avoid a misunderstanding of physical phenomena or errors in the collected documents.

- I am personally very fond of this aspect of personal research, obvious for motivated people.

The goals

- Each variation of a parameter or of experimental conditions should be fully understood.
- The operator should know the consequences of the particular action he is performing, where the device he controls is located and why it is used.
- It is obvious that I am not in favour of automat-operators who cannot react correctly when unexpected phenomena, which always sooner or later will appear, and will be unable to help machine physicists when they require more sophisticated controls, or deal with the user's stress in case of malfunction of the machine.

More

- Apart from the time devoted to the machine operation, it is compulsory to provide technical tasks to the operators.
- Active involvement in the creation of the routines and during machine studies.
- Always have a machine Encyclopaedia, near by the “Synchrotron Light” CD-ROM from the ESRF is a good example.
- A regular control of the knowledge acquired in theory and technical developments is necessary.

Realisations and contributions

Beside the routine operation of the facility, their knowledge allows them to improve the reliability and to develop sophisticated controls. I give some examples:

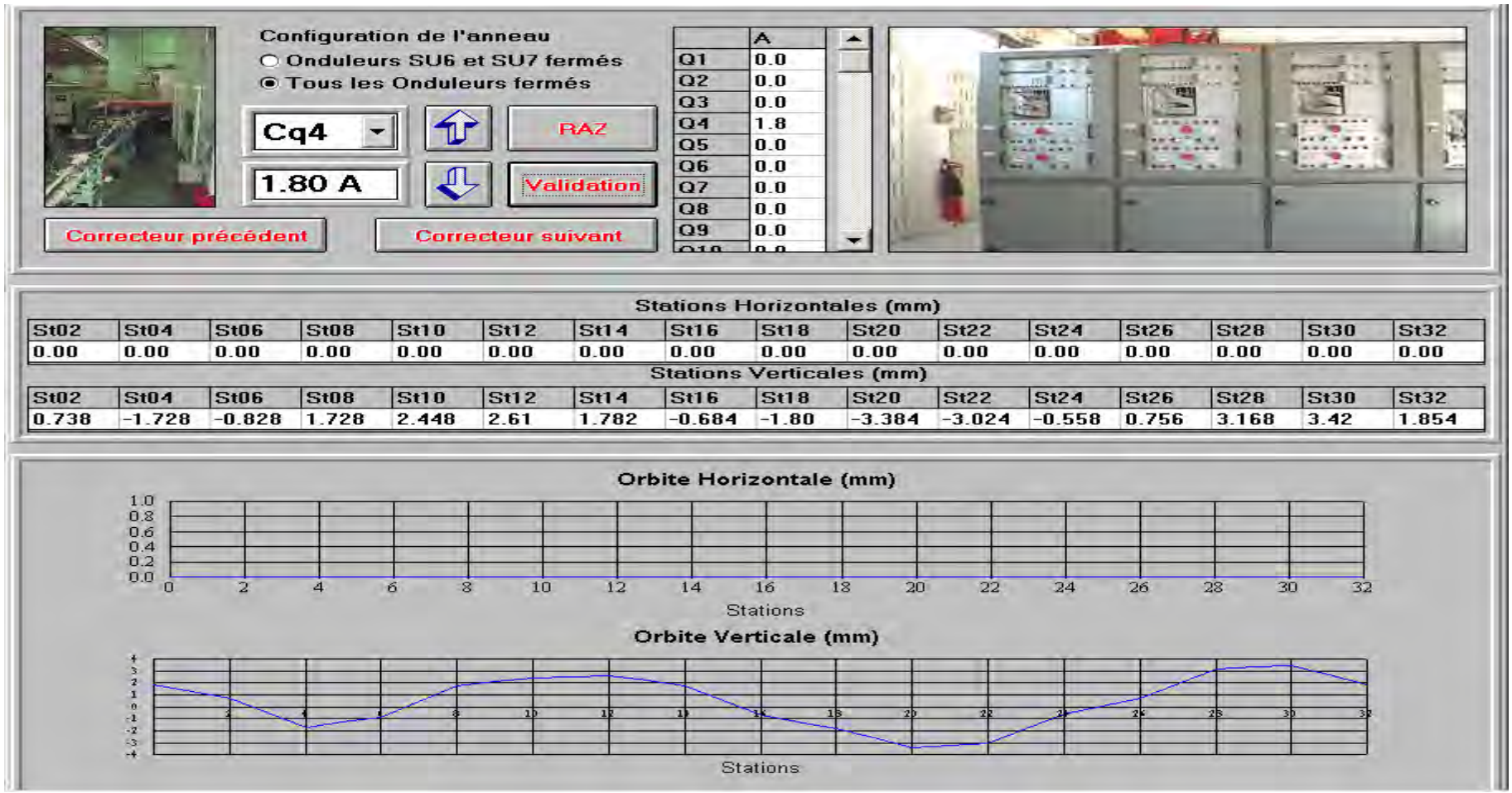
- Multiplexing of analog signals.
- Multiplexing of video signals.
- Study of a dedicated beamline for the use of optical diagnostics.
- Digital feed back on tunes
- Analog feed back system on tunes
- Realisation of the modelisation program.
- Realisation of the supervision program.

This list is of course incomplete and other contribution is for example :

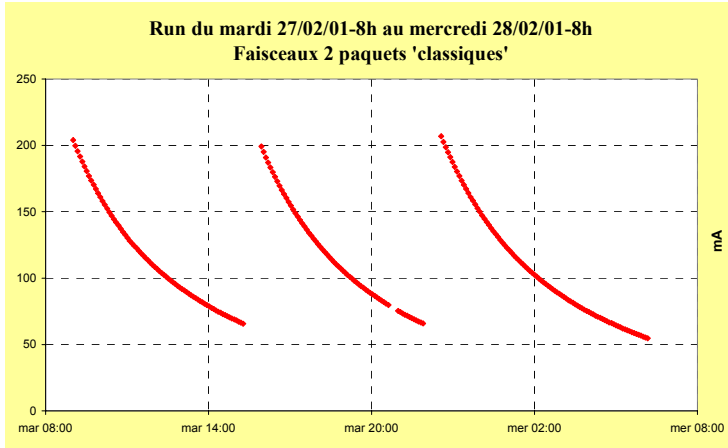
Diagnostic and proof of evidence of an orbit drift due to a quadrupole displacement because of the vacuum chamber thermal expansion.

Finally, operators play a very important role in the machine studies.

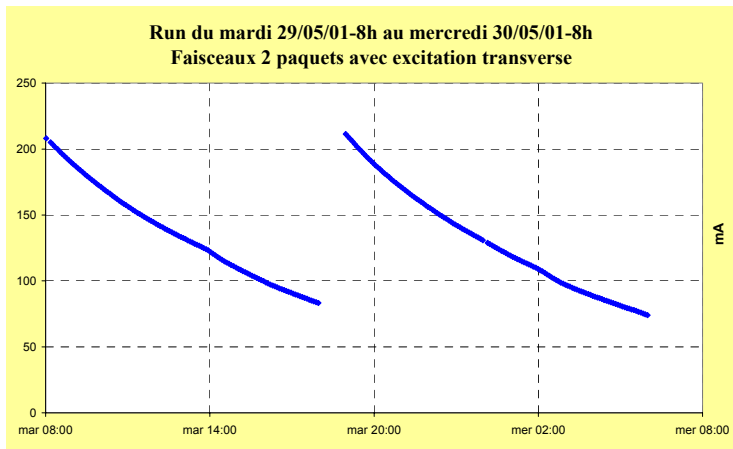
Their Contribution (Modelisation program)



Their Contribution
(Analog feed back system on tunes)



This system allows to enhance the beam lifetime and consequently instead of having 3 injections per day, we have only 2 injections a day.



CONCLUSION

- The control room is the heart of the facility.
- The operators at work in the control room should be motivated and efficient.
- The operator group is very often the only link with the users, and also the living memory of the installation (operation problems and others).
- No improvement operation and efficiency is possible without a group of several people with various technical backgrounds, associated from the beginning of the machine conception, of its controls and acquainted to the various routines.
- Their suggestions have to be carefully studied and taken into account.