Diagnostic Tools seen by the Control Room

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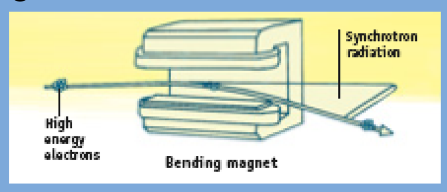
A light for science

ESRF

Electrons emitted by an electron gun are first accelerated in a linear accelerator (linac) and then transmitted to a circular accelerator (booster synchrotron) where they are accelerated to reach an energy level of 6 billion electron-volts (6 GeV). These high-energy electrons are then injected into a large storage ring — 844 metres in circumference — where they circulate in a vacuum environment, at a constant energy, for many hours.

Inside the storage ring

The storage ring includes both straight and curved sections. As they travel round the ring, the electrons pass through different types of magnets. These include:

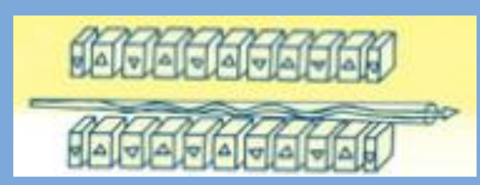


Bending magnets

When the electrons pass through these magnets, they are deflected from their straight path by several degrees. This change in direction causes them to emit synchrotron radiation.

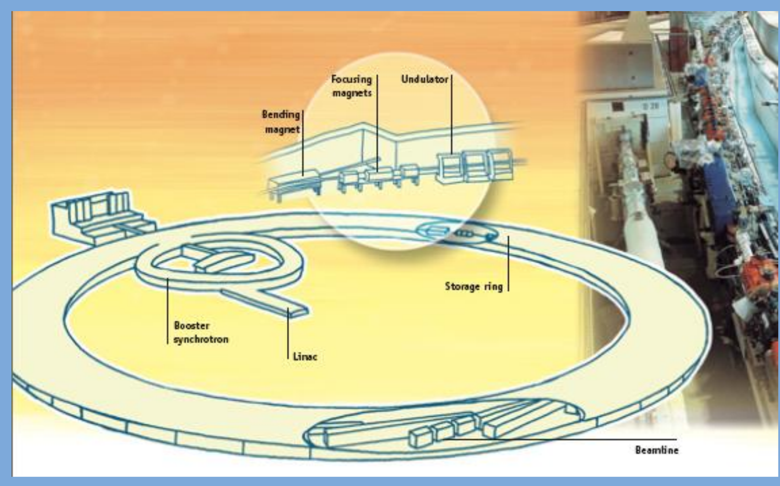
Focusing magnets

These magnets, placed in the straight sections of the storage ring, are used to focus the electron beam to keep it small and well-defined. A small and well defined electron beam will produce the very bright X-ray beam needed for experiments.



Undulators

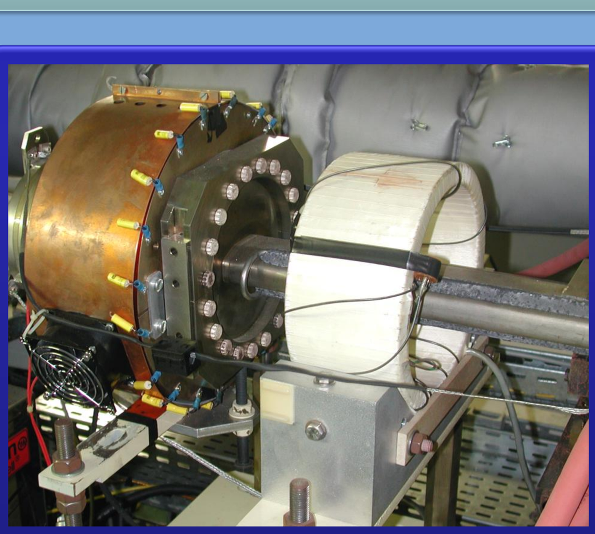
These magnetic structures, made up of a complex array of small magnets, force the electrons to follow an undulating or wavy trajectory. The beams of radiation emitted from the different bends overlap and interfere with each other to generate a much more intense beam of radiation than that generated by the bending magnets.



The synchrotron beams emitted by the electrons are directed towards the "beamlines" which surround the storage ring in the experimental hall.
Each beamline is designed for use with a specific technique or for a specific type of research.
Experiments run throughout the day and night.

In order to quantify, qualify and finally improve the Beam tuning, we need many DIAGNOSTIC TOOLS which are:

Current Transformers



To measure the total current in the machine or the current in one bunch out of the 992 bunches, there are 2 types of current transformers.

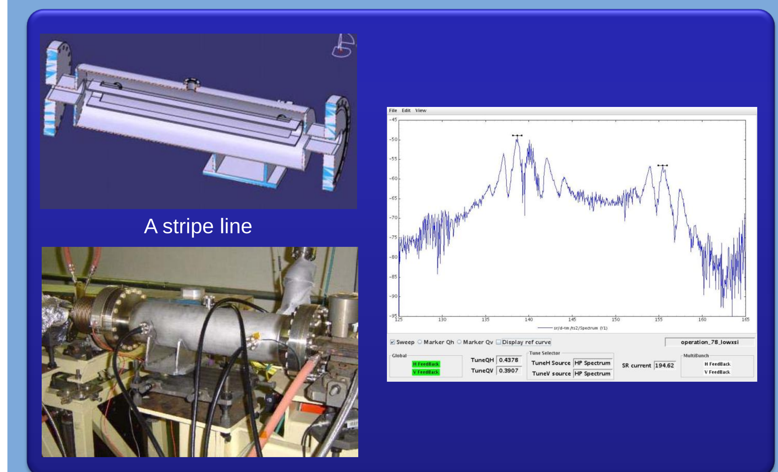
-The Parametric Current Transformers for the total current.

-The Integrated Current Transformer which allows the measurement of the current in a specific Bunch.

These allow us to calculate the lifetime of the beam.

Tune Monitor

The TUNE Monitor performs the measurement of the fractional part of the tune (number of betatron oscillations done by the beam) of the machine in the vertical and horizontal planes.



A stripe line

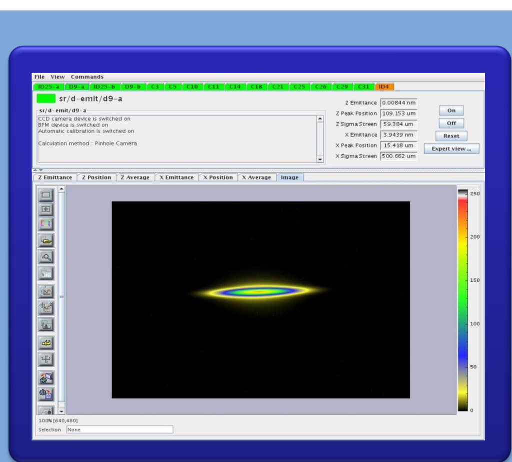
To measure the tune, we have to excite the beam and to pick up the signal which is analyzed by a spectrum analyzer.

A strip line is used to do these two functions.

The tune can also be computed using the Libera BPM system.

The perfect adjustment of these oscillations is necessary for the correct tuning of the machine. (Lifetime, minimization of resonance effects…)

Emittances

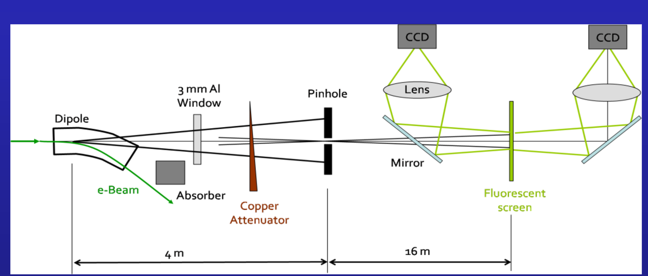


The Emittance measurement allows us to:
- visualize the transverse profile of the electron beam.
- calculate the emittance and size of the beam.
- give the position stability of the machine.

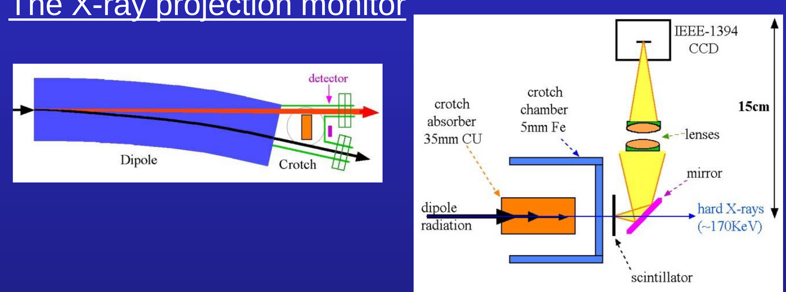
We can see the Radio frequency instability (HOM).

There are 15 emittance measurments all around the Storage Ring taken using 2 different technologies.

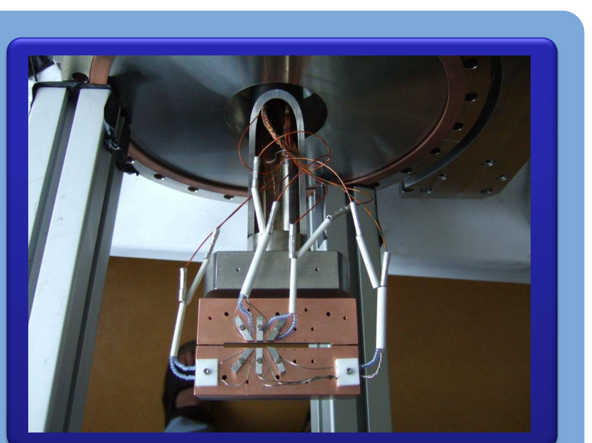
The Pinhole Camera



The X-ray projection monitor



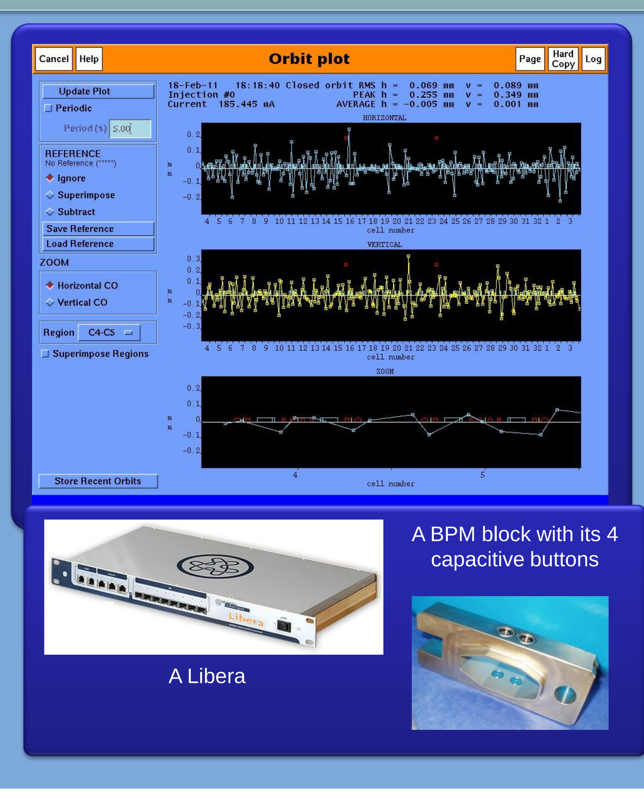
Fuses



There are two fuses on the storage ring,
A fuse consists of 2 blades (up & down) separated vertically by 2mm with 3 thermocouples mounted on each of them.
The fuse is in vacuum and aligned on the photon beam.

In the case of a strong vertical beam blow up or a rapid vertically oscillating beam position, the temperature rises. A threshold is fixed to kill the beam and avoid damage.

Beam Position Measurement



A BPM block with its 4 capacitive buttons

A Libera

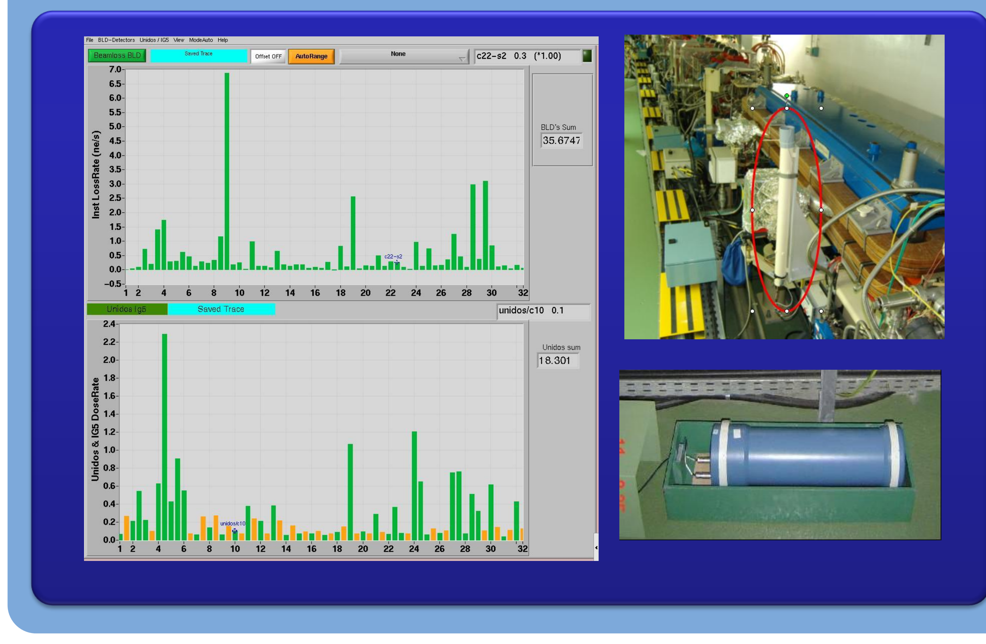
This allows the precise measurement of the position of the beam all around the Storage Ring (844m).There are 224 BPMs; with these monitors we can correct the orbit with 192 steerers (96 in each plane). These BPMs are processed by a Libera Brillance System (since the end of 2009).
We use them to correct this orbit every 30 seconds.

But, these BPMs are very fast, so we can determine the position either turn by turn or on the first turn of the electrons, if there are any problems.
e.g. during the restart, faulty steerer….

8 of them are used as Vertical Interlocks (BPI) in case the beam is out of its orbit; they kill the beam to avoid damage…

Beam Losses Detectors

These devices are used to detect losses on the machine.



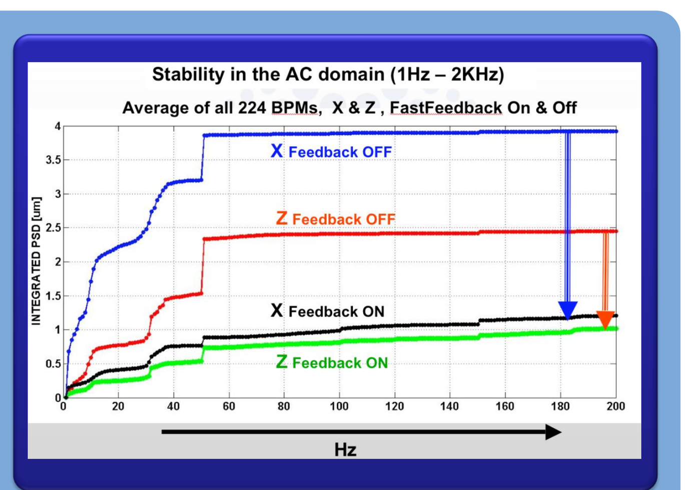
With this system, it is possible to quantify the consequences of a bad vacuum in a sector, a misalignment of a vacuum vessel, a mistuned orbit or an obstacle in the electron beam…

2 types are used (64 of each):

The Slow Beam loss detector is a scintillator vertically centered on the beam.

The Unidos is a ionization chamber on the floor under the dipole.

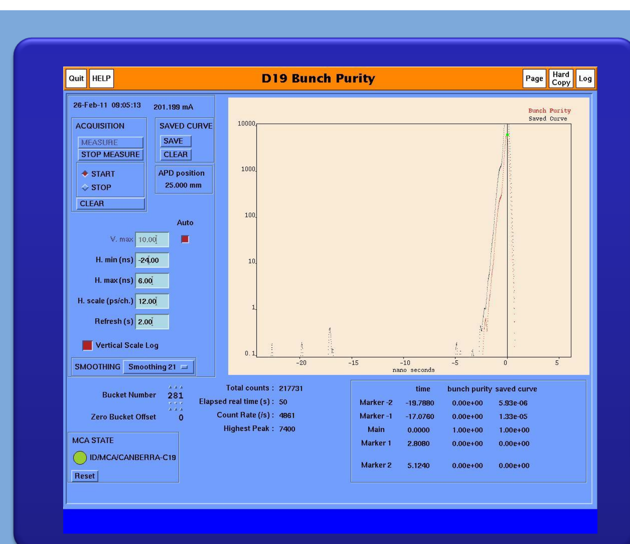
Fast Orbit Correction



The Beam lines need to have a beam which is as stable as possible.
The Fast Orbit Correction stabilizes the beam in high frequencies (from 1Hz to 2kHz).
To do this, a system of Fast BPMs (32) is used which works at 4.4kHz and performs a correction in the vertical and Horizontal plane with Fast Steerers (16 Verticals & 32 Horizontals).

In the near future, this system will work with the 224 BPMs of the machine and the 192 steerers of the normal correction and at 10 KHz to improve the stability of the beam.

Bunch Purity



For some experiments, we don't want parasitic electrons between the main bunches, so the beam is cleaned using a shaker and a scraper…

We use the Beam Purity measurement to check the level of this purity.

The shaker excites the beam in a frequency domaine which doesn't perturb the main bunches but affects the polluted bunches which are excited and then strike a scraper which is on their trajectories.

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