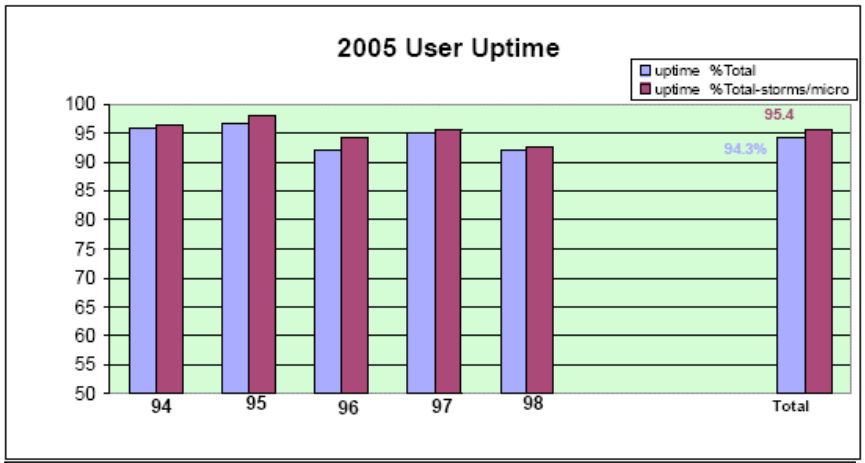
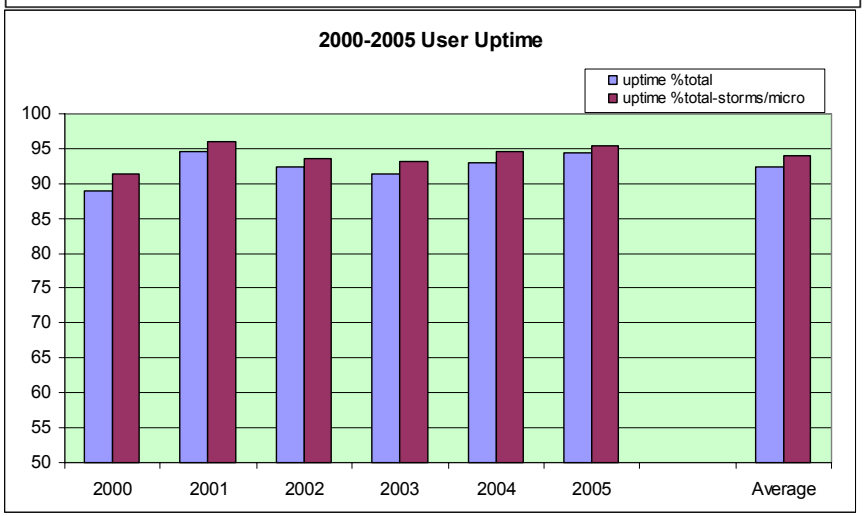
Status of the 3rd Harmonic SC Cavity at Elettra

Night shift at the Elettra Booster building yard, ***5th July 2006***

ELETTRA Operation

- 24 hours per day operation periods of **4** to **8** weeks are separated by shutdowns.
- ELETTRA operates for users at 2 different energies: **2.4 GeV** (25% of user's time) and **2.0 GeV** (75% of user's time).
- Injection Energy is **0.9** GeV.
- Nominal beam current intensity is **150 mA** at **2.4 GeV** and **330 mA** at **2.0 GeV**.
- Uptime for Users is typically close to **95%.**



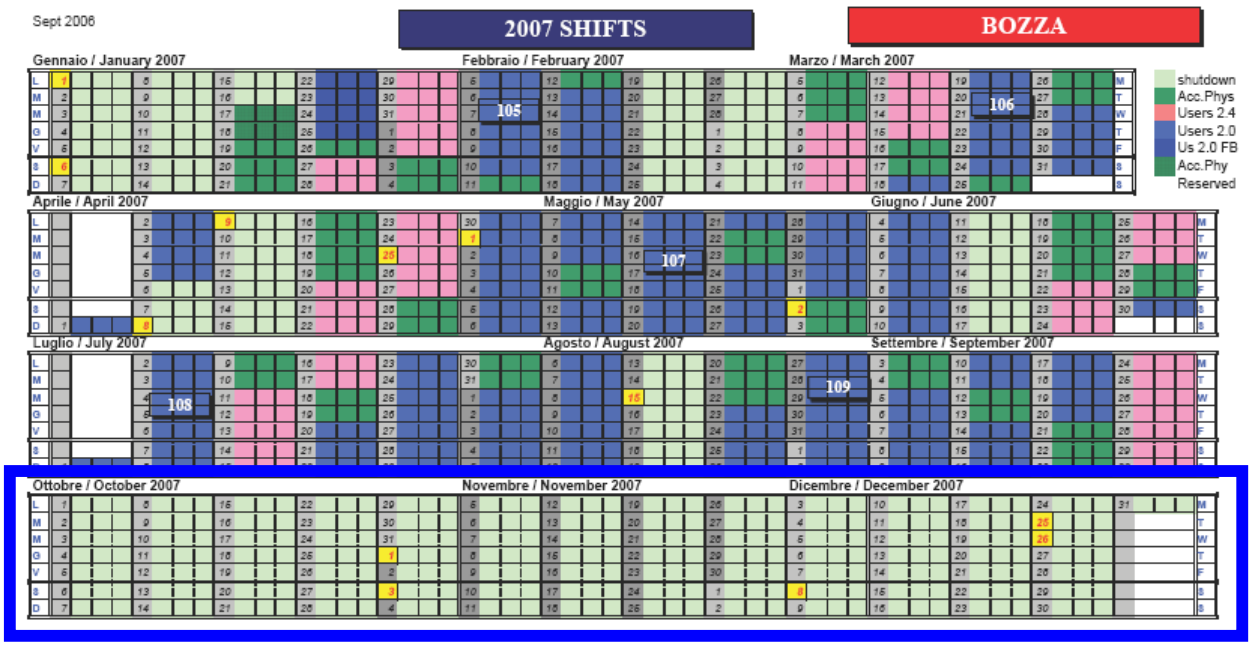


ELETTRA Upgrades

At Elettra we are presently quite busy with the Upgrade Projects: **Full Energy Booster Injector, RF Upgrade, Global Orbit Feedback.**

Deadline: **end 2007**

In this **DRAFT calendar** for Elettra operations in 2007, a 3 months shutdown is foreseen in Autumn, to allow the connection of the new booster to Elettra.



In parallel activities for the X-ray FEL FERMI @elettra *are also taking off.*

Upgrades: Booster building as of 25/9

Construction of the new booster building is going on in the centre of the storage ring building.

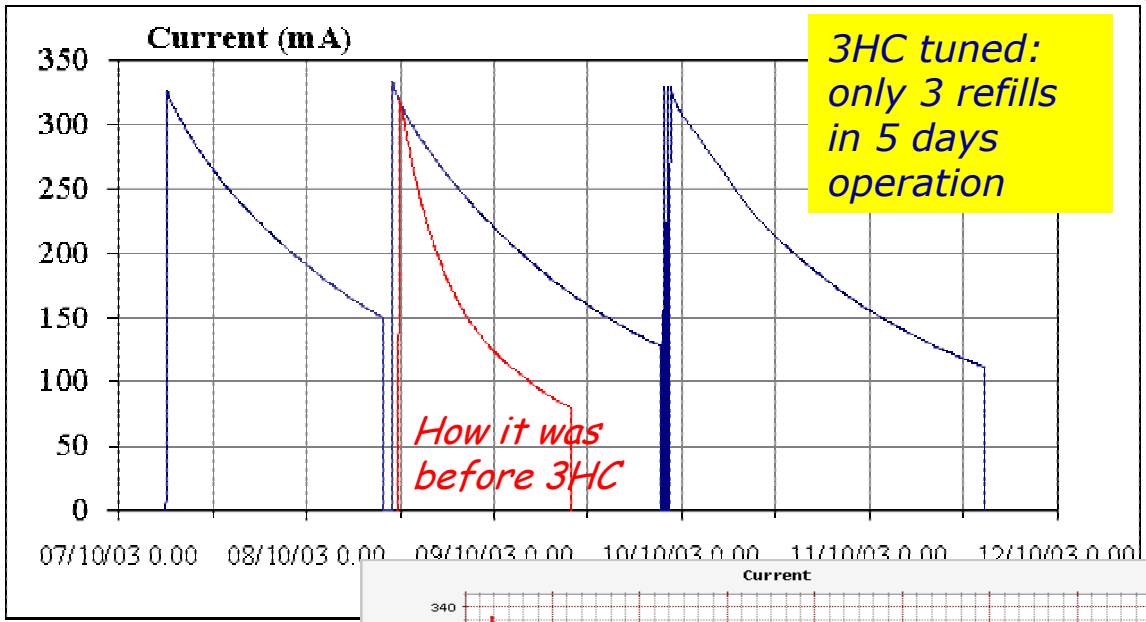
Pre-injector tunnel

Booster Tunnel

Operations with SUPER-3HC, update

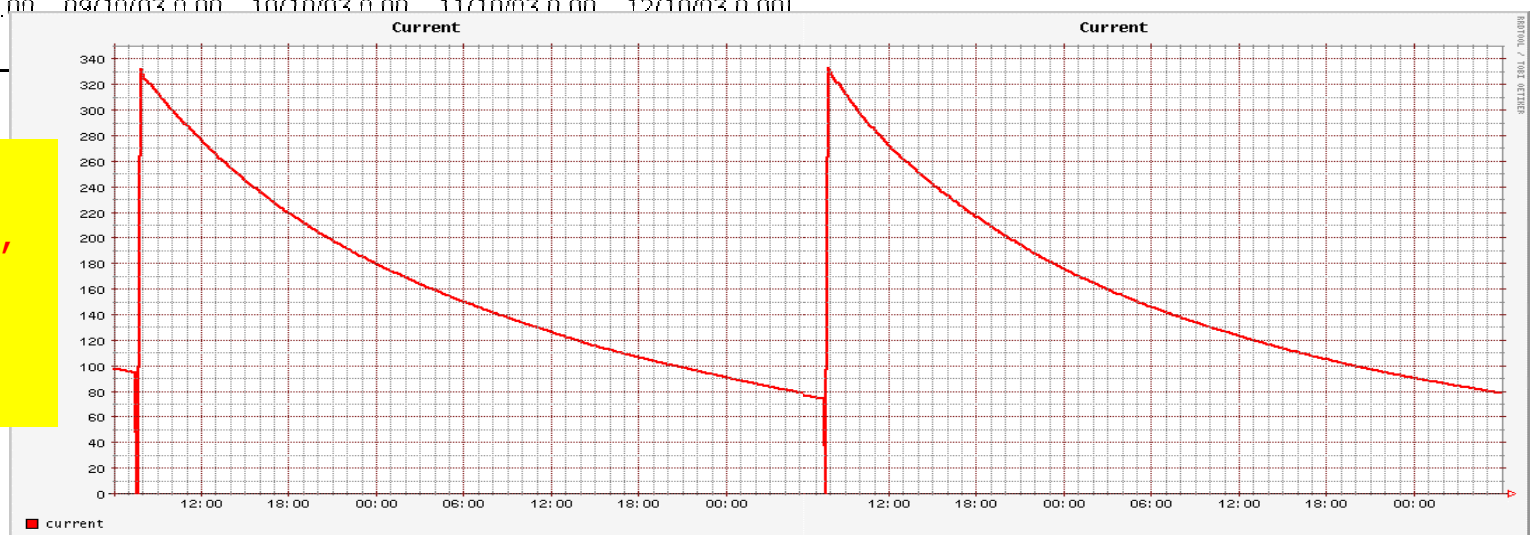
- Typical lifetime value we can obtain when activating the 3rd harmonic cavity @ 320 mA, 2.0 GeV is **between 22 and 27 hrs.**
- Machine operation benefits from the lifetime increase: since **2005** refill at **2.0 GeV** is performed every **48 hrs**.
- Longitudinal Coupled Bunch Instabilities are **cured** by 3HC.
- The **overall** reliability of the superconducting cavity and of its cryogenic plant is good.
- However, despite the care given to maintenance, operation could be smoother.

Operations update: refill every 48 hours



- Before 3HC, refills were performed every **24** hours.
- First, with 3HC tuned, refill time was increased to every **36** hour (final current **140-150 mA**)
- Since 2005, users agreed to refill every **48 hours** (final current **100 mA**)

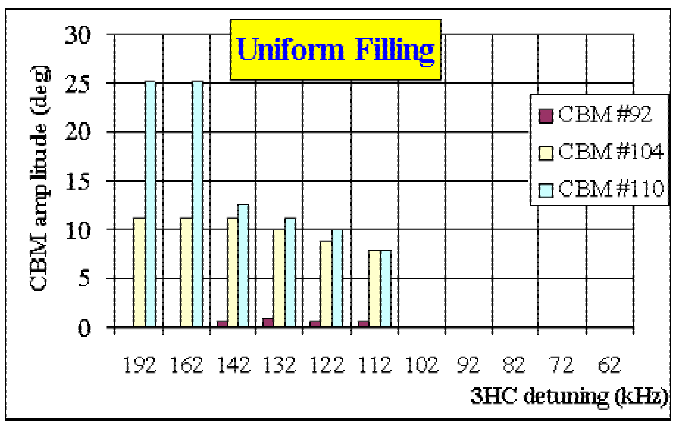
Beam current decay at 2.0 GeV, **1-4** February 2006, injecting every **48** Hours



SUPER-3HC cures CBM instabilities (Landau damping)

The Landau damping induced by SUPER-3HC is very powerful in curing the longitudinal coupled bunch mode (CBM) instabilities.

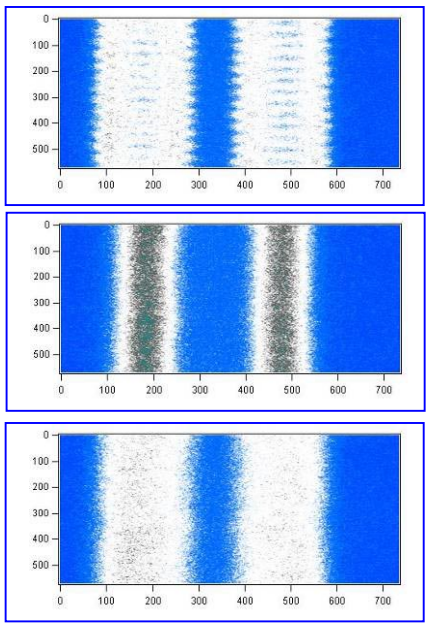
By activating the 3HC cavity for the first time at ELETTRA a **longitudinal CBM instability-free beam** was measured, at **320 mA, 2.0 GeV.**



Δf= +112 kHz

Δf= +92 kHz

Δf= +62 kHz



Longitudinal **UNSTABLE** Beam

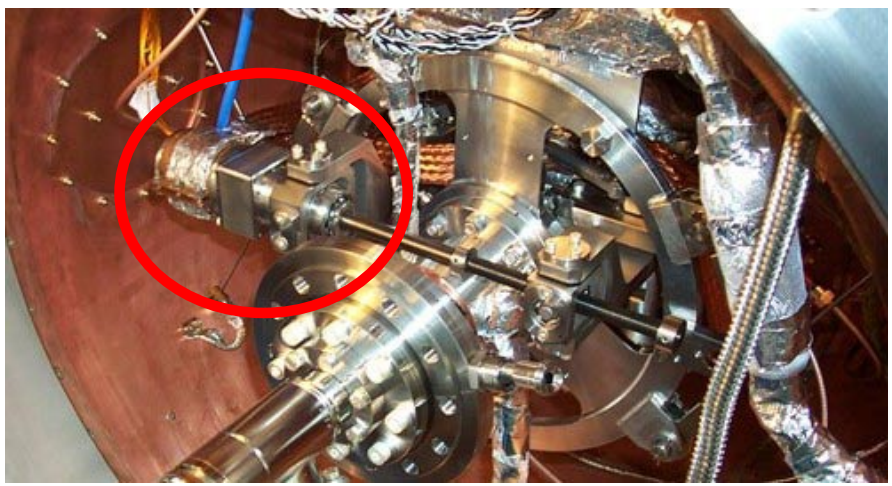
Longitudinal **STABLE** Beam

Bunch Length is Increased

Uniform Filling

Failure report: Mechanical Tuning System

- At the 2005 meeting we reported about the periodical failures of the tuning system of the cells:
  March 2003 (cell 1); December 2003 (cell 1); May 2005 (cell 2).
- A thermal problem on the gear boxes has been identified. Following CEA indications, we set a smoother and slower operation mode of the SINCOS motor driver. This has been effective since January 2006.
- Presently we activate only cell nr. 2, at higher voltage.
- Cell nr. 1 movement shows a few % reproducibility errors and is now kept idle.
- Waiting for more robust gear boxes from CEA.



May 2006: Compressor failure

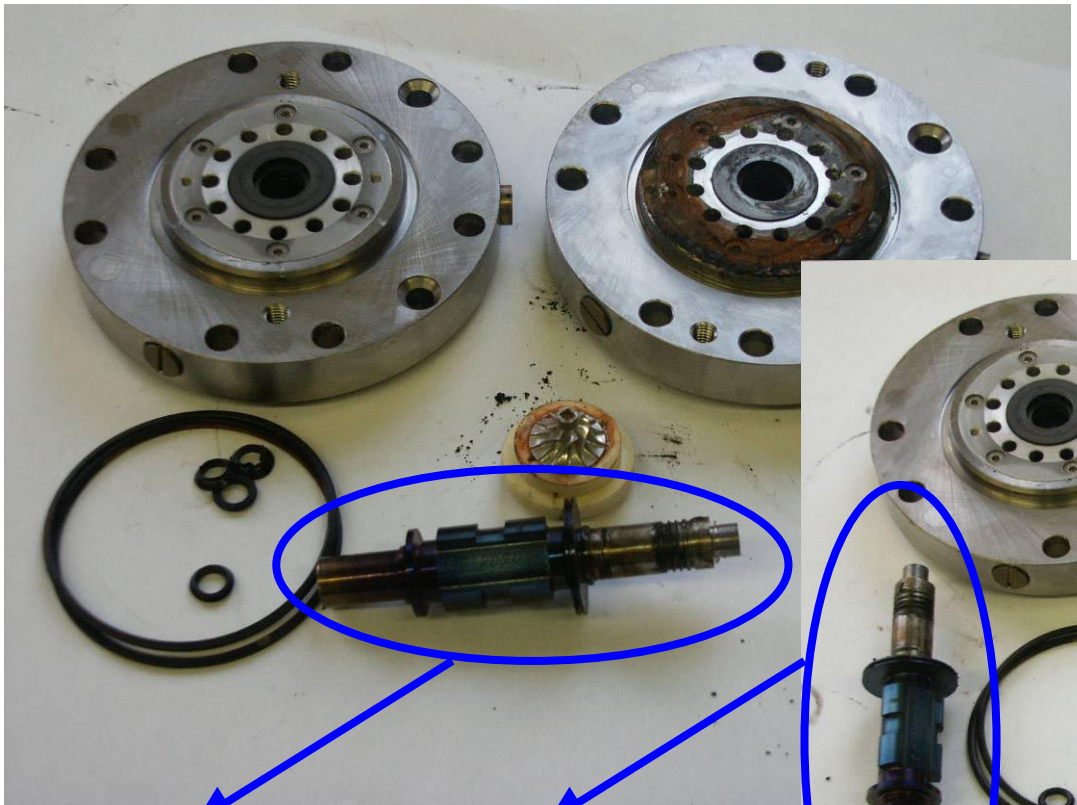
- End of May, in the very last days of Run 101, the compressor stopped due to too high temperature of the Helium gas. Cooling air filters were found stuck.
- They are periodically cleaned. Following the normal interval, cleaning was foreseen during the June/J
- Why was the normal interval not sufficient? The compressor barrack is located close to the **booster building yard** and this Spring there was heavy truck traffic in the area, with a lot of dust produced.

Trivial fault, must be avoided, caused 8.7 hours of user's downtime.

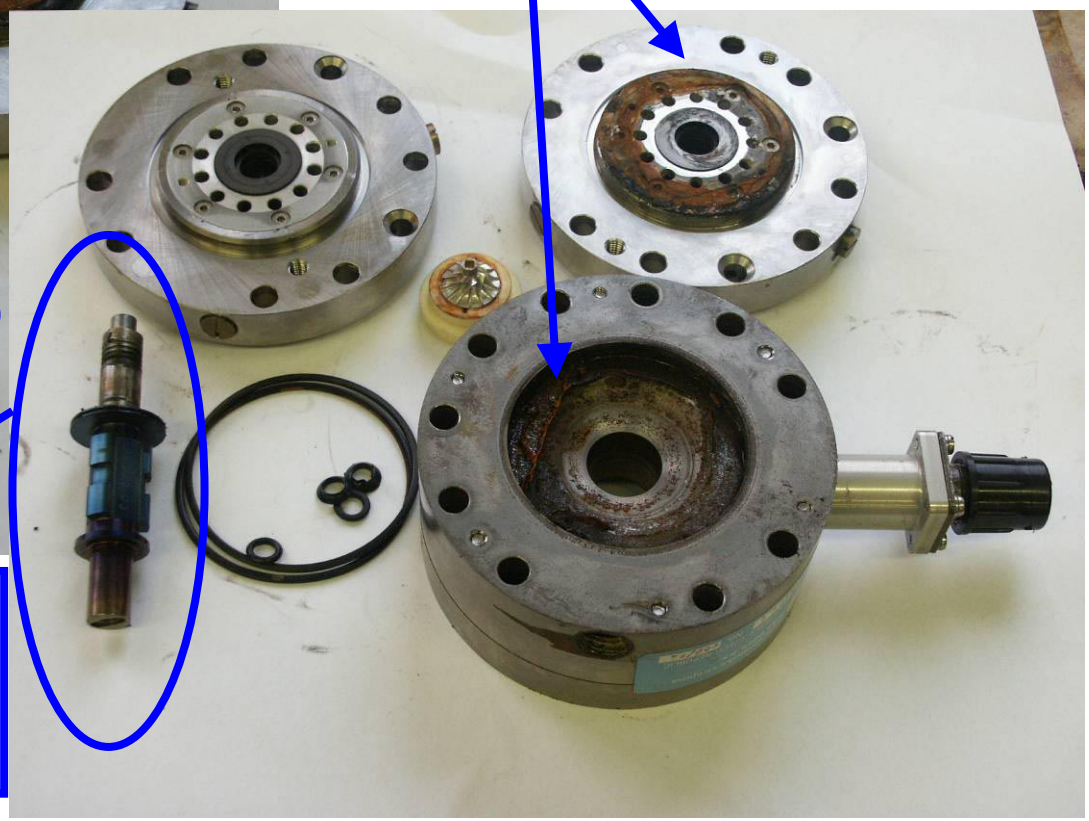
July 2006: Turbines failure – The event

- Between July 3rd and July 14th we performed the annual maintenance of the HELIAL 1000. After maintenance **the liquefier could not be restarted**.
- The **turbine T1 shaft did not rotate**. Supplier of turbines PBS replaced both turbines with our spare set.
- Machine restart was **delayed by 4 days**. No delay caused on user's operation, but several accelerator physics shifts cancelled. Downtime computed on the new established starting date of the ring, so only **8** hours downtime to 3HC.
- Once back to the factory, PBS carefully investigated the turbines housing and the turbines itself.

July 2006: Turbines failure – TURBINE 1



Rust on turbine casing.

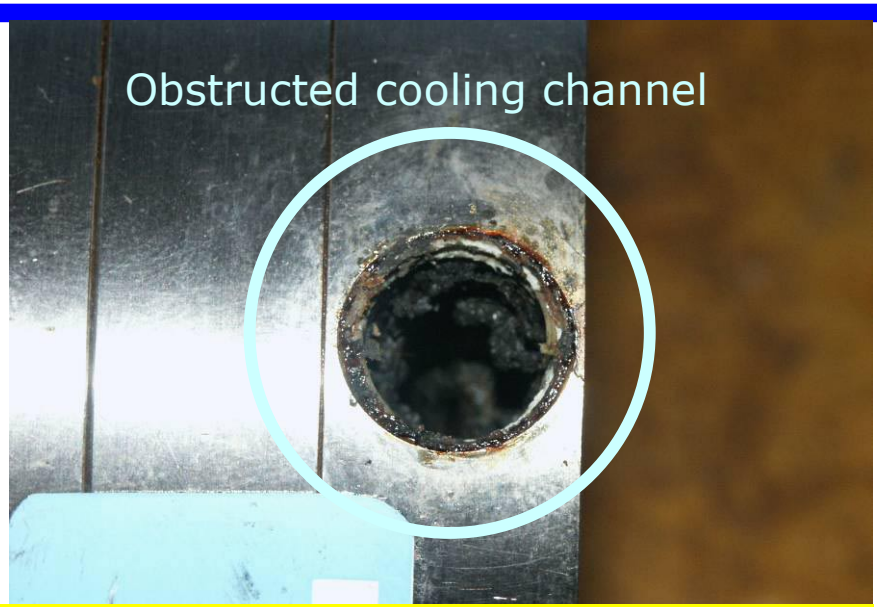


Turbine shaft with some rust; some parts coloured dark blue and/or violet.

July 2006: Turbines failure - WHY?

The official report of PBS states that *"the failure was caused by bad cooling of the inner parts of the turbines casing. PBS states that the eddy current brake cooling pipes were obstructed by sediments and impurities deposited by the cooling water".*

Impurities found in the circuit



The cooling circuit of the turbines was connected to our main magnets cooling circuit and is demineralized, treated and filtered.

So we hardly can agree that the cause stays in our cooling system, we much more believe that the cause are the turbine cooling channels, which are made of **nickel plated steel** (no s.s.)

This is the same conclusion of our colleagues at the Swiss Light Source which have experienced very similar problems.

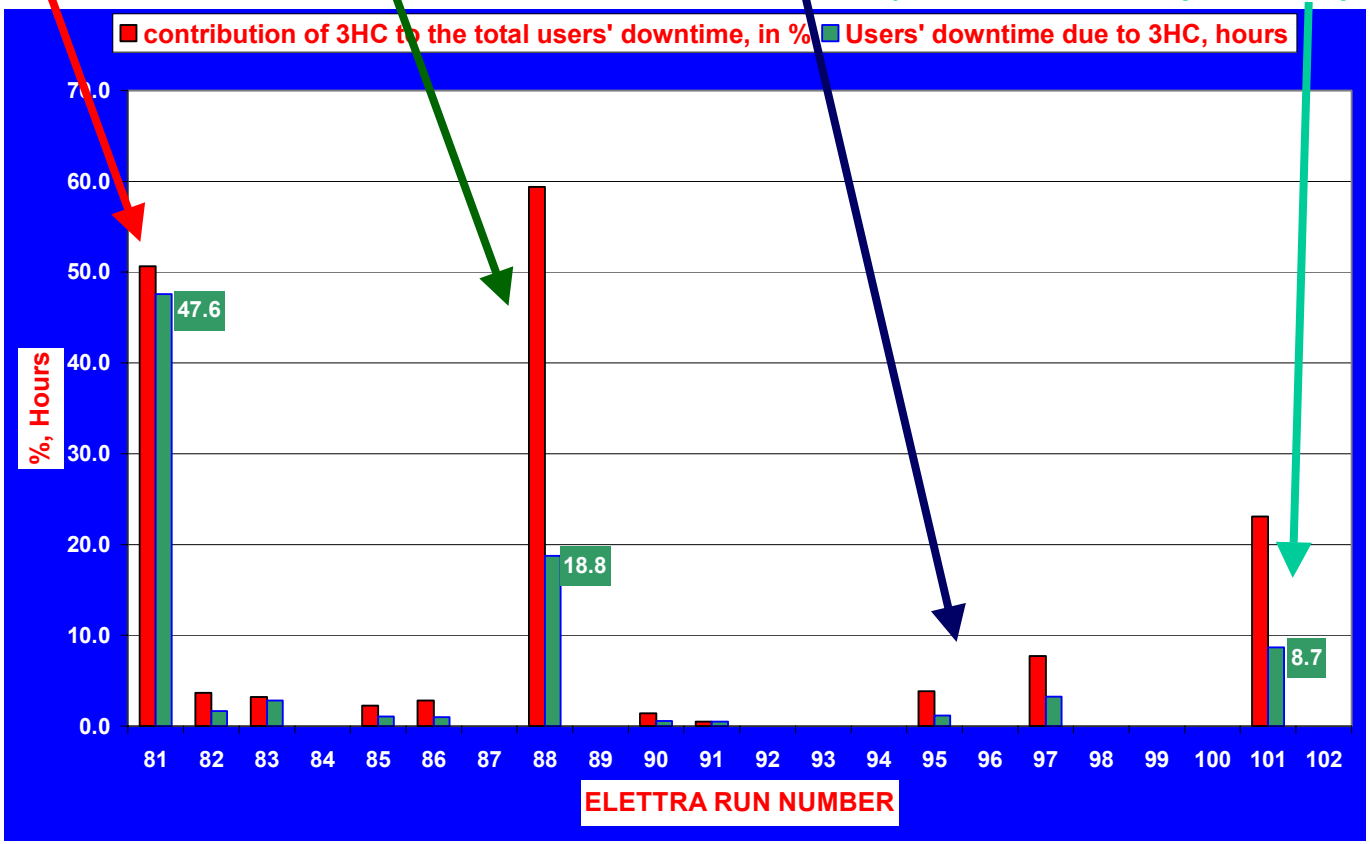
SUPER-3HC Reliability and Uptime

Downtime reasons:

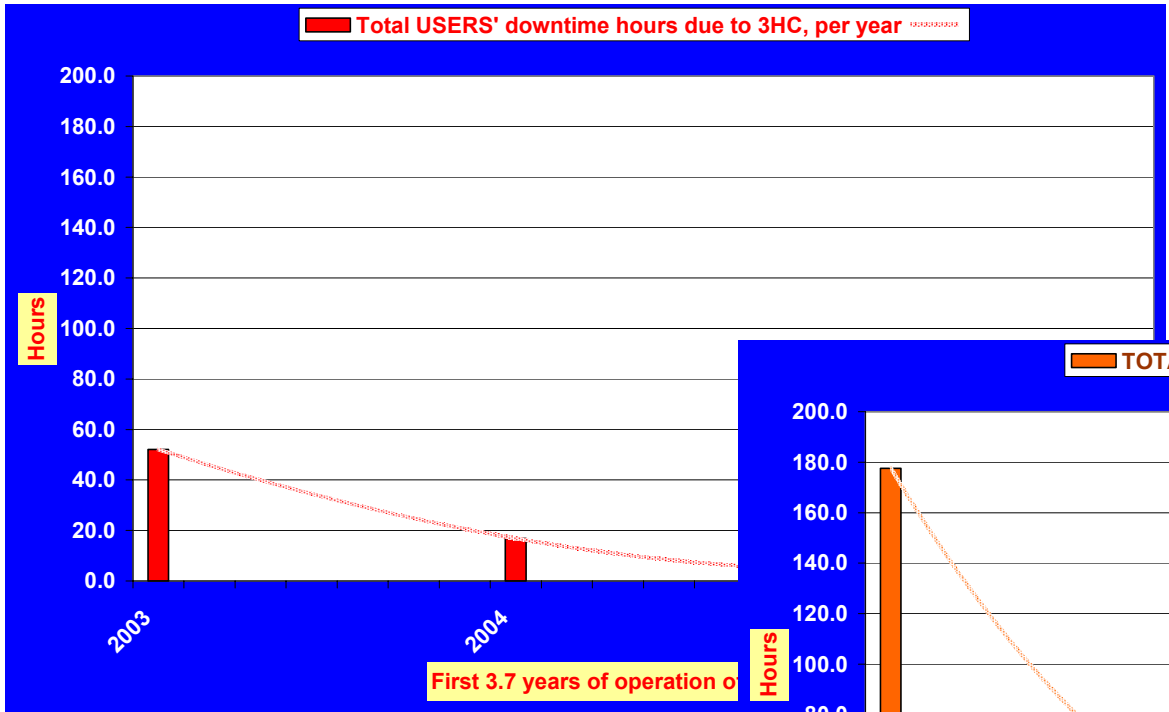
- Leak in a Helium line (run 81)
- Pre-Vacuum pump failure (run 88)

Downtime reasons:

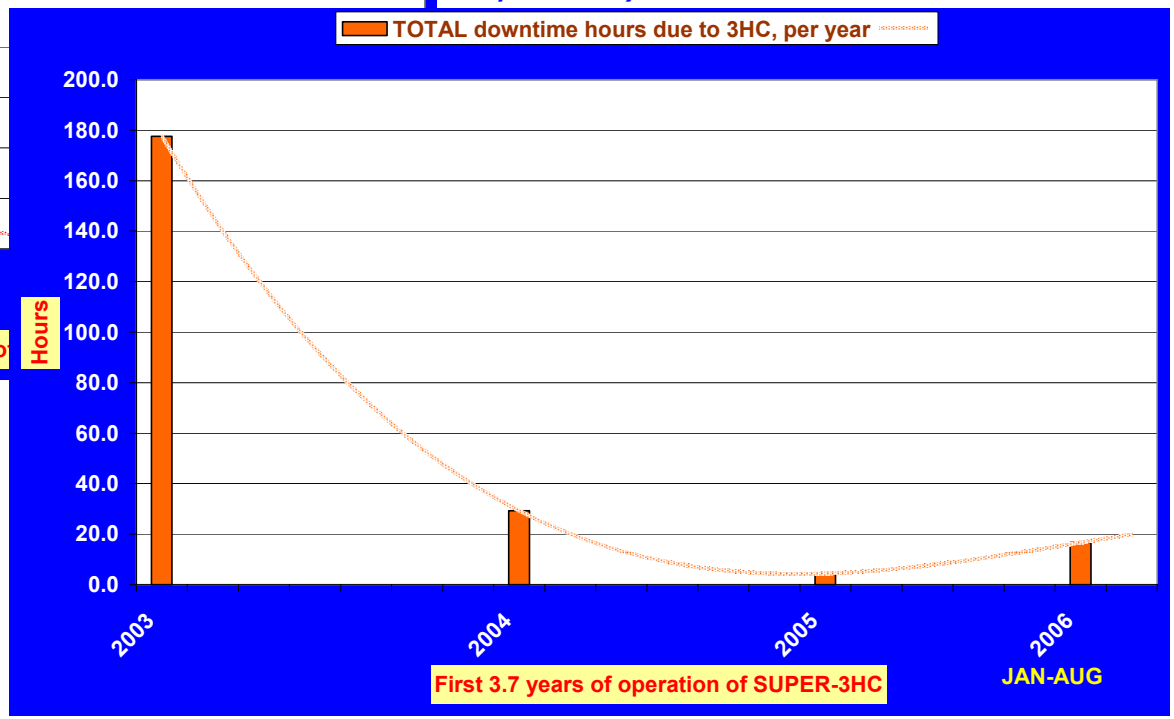
- Mechanical Tuning system failure (runs 95 and 97)
- Compressor failure (run 101)



SUPER-3HC Reliability and Uptime



Overall reliability is good.
Downtime shows "bathtub" behaviour.
However, this statistic doesn't show stops due to external electric power failures and thunderstorms, or faults happening during shutdowns (as in July 2006).



Need still to improve reliability by:

- *Even more* careful maintenance
- Improving services (vacuum, water, electrical power)
- Definitely fixing the frequency tuning system failures

Conclusions

- **SUPER-3HC contribution in ELETTRA brightness increase:**
  - Lifetime is increased by a factor **3 to 3.5**
  - The Longitudinal Coupled Mode instabilites are **suppressed**.
  - Injection every **48 hours** is now Elettra **standard** at **2.0 GeV**.

- ***Overall reliability of the SC Cavity and of the Cryogenic plant is good, but shall still be improved:***
  - Careful maintenance is recommended.
  - Highly reliable ancillary systems (water, electricity, vacuum) are a must.
  - The system is efficient even with only one cell in operation.

- **Weak points in the system:**
  - The mechanical tuning system (gear-boxes) of the cells. Being upgraded in collaboration with CEA-Saclay.
  - Turbines cooling system, material of the housing and cooling channels. Action in collaboration with SLS to ask for a new design by Air Liquide/PBS.