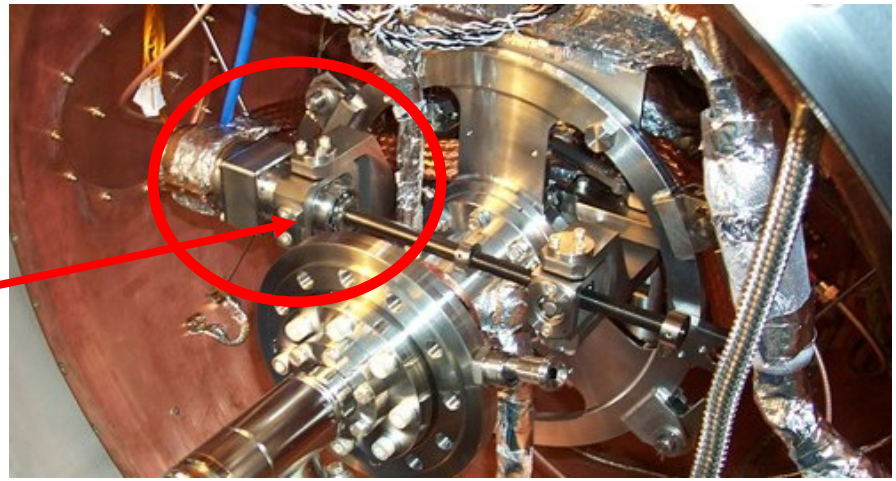
3rd Harmonic Cavity at ELETTRA

- Standard operation at 2.0 GeV foresees 3HC activation.
- Longitudinal Coupled Bunch Instabilities are **cured** by 3HC.
- **Lifetime** depends on ultimate vacuum conditioning and filling pattern, the typical value we can obtain @ 320 mA, 2.0 GeV is **between 22 and 27 hrs.**
- Machine operation benefits from the lifetime increase: refill at 2.0 GeV is performed every **36 hrs**.
- Cryogenic plant (Compressor/Cold Box/Transfer Line and valve box) is reliable; **NO** significant faults were registered since last meeting. Thanks to better financial conditions we can now upgrade some external services (e.g. water system) and buy more spares (e.g. turbines).

- Periodical failures of the mechanical tuning system of the cells have been registered:
  March 2003 (cell 1); December 2003 (cell 1); May 2005 (cell 2).
  In these occasions the gear boxes have been always found stuck. We suspect that a thermal problem is the cause.

- Presently we operate with only one cell. By increasing the voltage on this cell we can still obtain the performance in terms of HOM damping and lifetime increase.

We are investigating possible solutions. The most feasible one could be to increase the cooling efficiency on the core of the gear box



- At ELETTRA we use a partial filling of the bunch train. Experiments with 3HC allowed to set a filling that optimizes the lifetime increase: 96% bunch train, 4% empty gap.
- The gap induces a the phase modulation over the bunch train. This effect and the bunch overstretching around the optimum harmonic voltage have been analysed in several streak camera experiments until December 2004, in the frame of *G.Penco's PhD Thesis*: *"The SUPER-3HC project: a superconducting third harmonic cavity at ELETTRA", Milan 12/2004*
- *A short overview of the results not already presented one year ago at Daresbury will follow.*

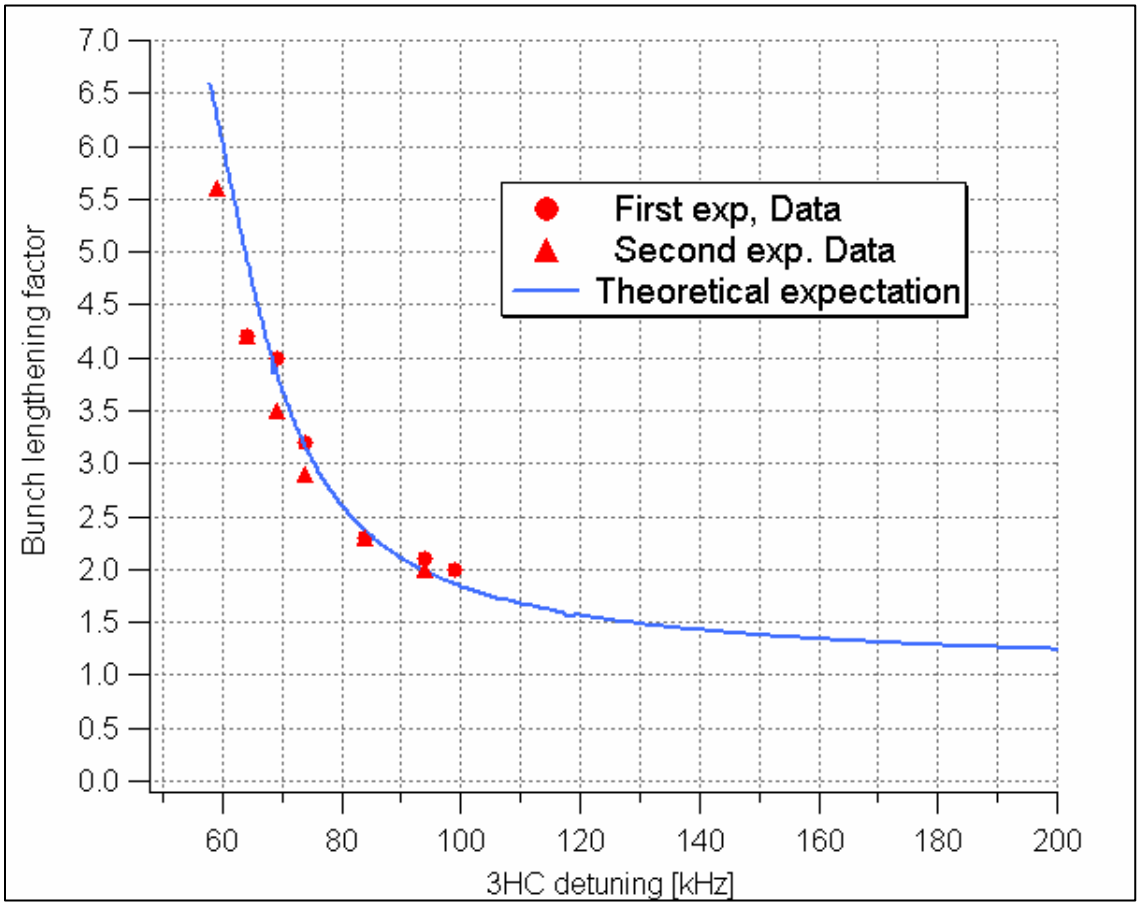
Comparison experiments / theory of σ/σ_0 for uniform filling

We measured the RMS bunch length at zero current and with 3HC parked : **22.6 ps.**

The theoretical expectation is the ratio between the bunch length computed with and without a 3rd harmonic potential.

The measured data fit quite well to the expectation.

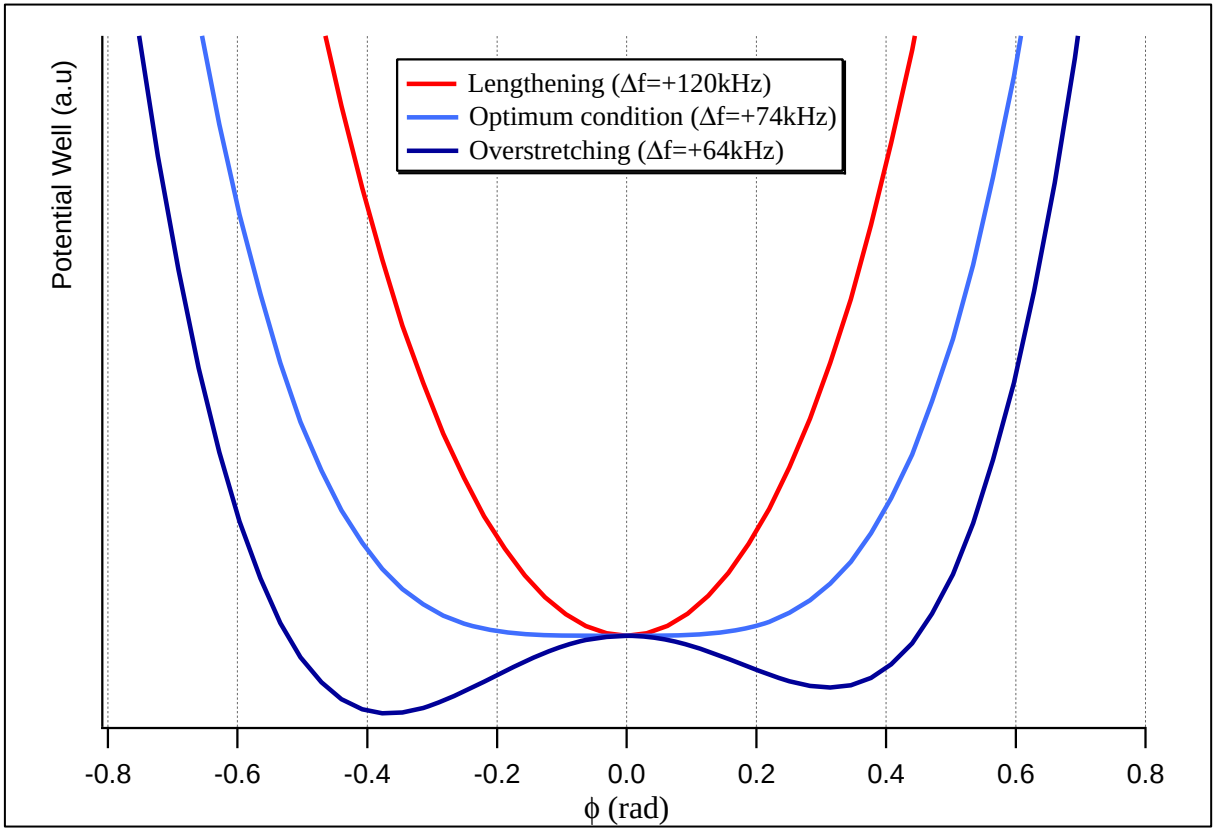
3HC usual working point is at 64 kHz (@ 320 mA).



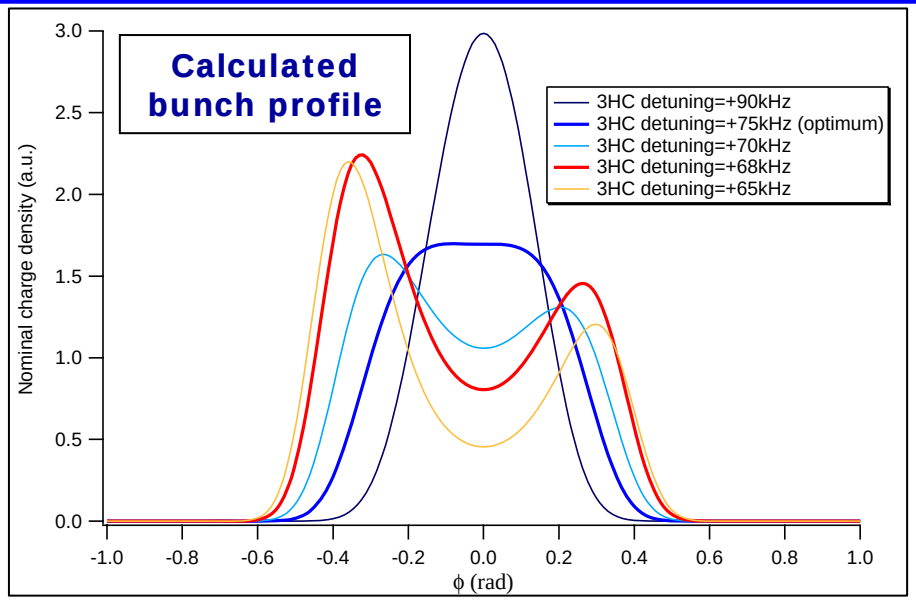
Overstretching

The 3HC detuning corresponding to the optimum harmonic voltage necessary to flatten the RF potential at 320mA is ~ **+74kHz** (f_{3HC}=1499.030MHz).

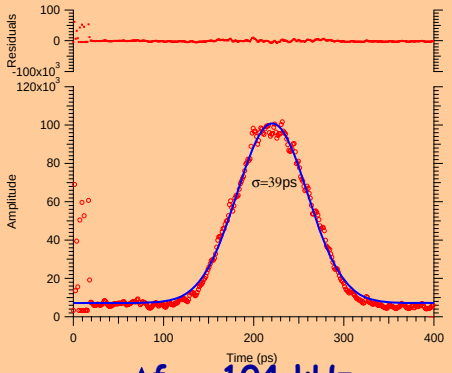
Detuning 3HC beyond this value creates a RF potential well distortion, with two stable points.



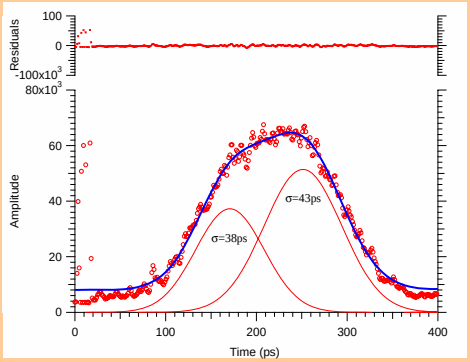
Overstretching in uniform filling



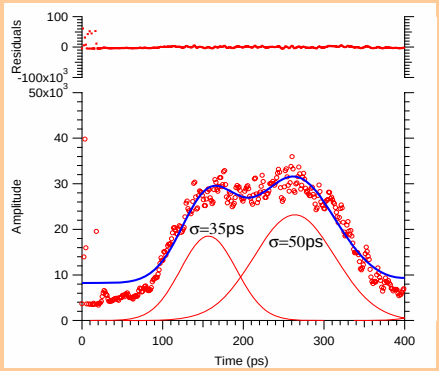
Experimental data fitting:



Δf= +104 kHz



Δf= +74 kHz



Δf= +64 kHz

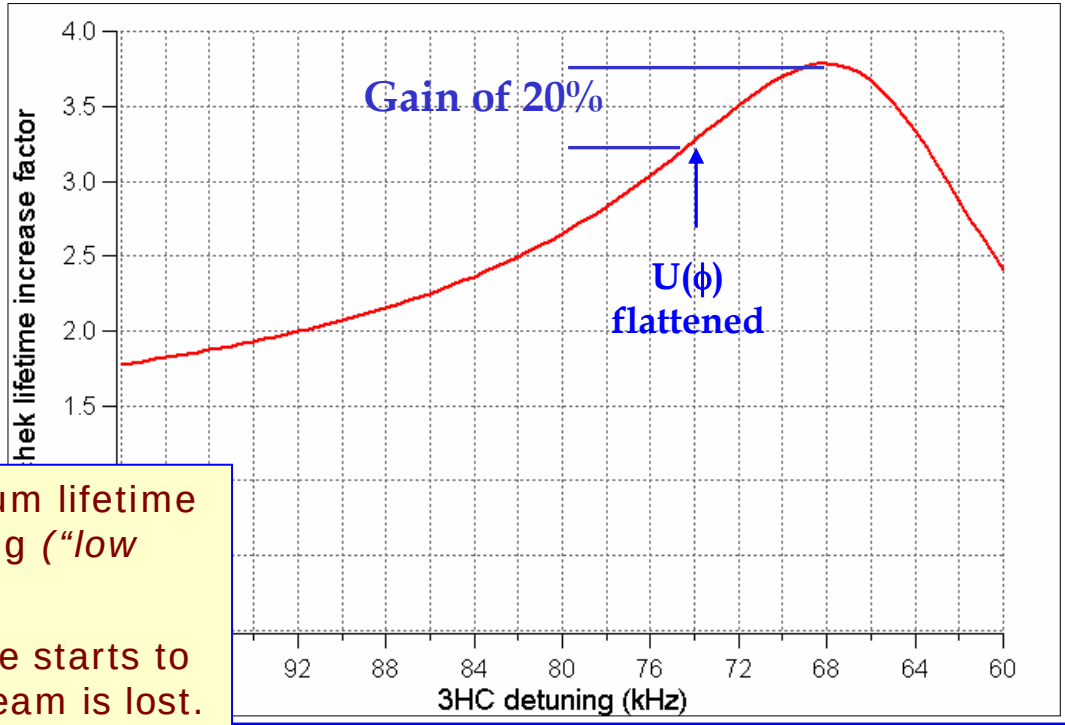
Overstretching and beam lifetime

The splitting of the bunch profile into two peaks *should degradate* the beam lifetime, but this is true only in case of strong overstretching. We observed that when we tune 3HC just beyond the optimum detuning, the distortion of the RF potential well is not so large to induce a relevant particle loss and it is well compensated by the increase of the rms longitudinal distribution.

Touschek lifetime increase factor
(Byrd-Georgsson, PRST-AB 2001)

$$R = \frac{\tau_{HC}}{\tau_{RF}} = \frac{\varepsilon_{HC}^2}{\varepsilon_{RF}^2} \frac{\int_{-\pi}^{\pi} \rho_{RF}^2(\phi) d\phi}{\int_{-\pi}^{\pi} \rho_{HC}^2(\phi) d\phi}$$

Calculating the Touschek lifetime increase factor **R** at 315mA vs the 3HC detuning:



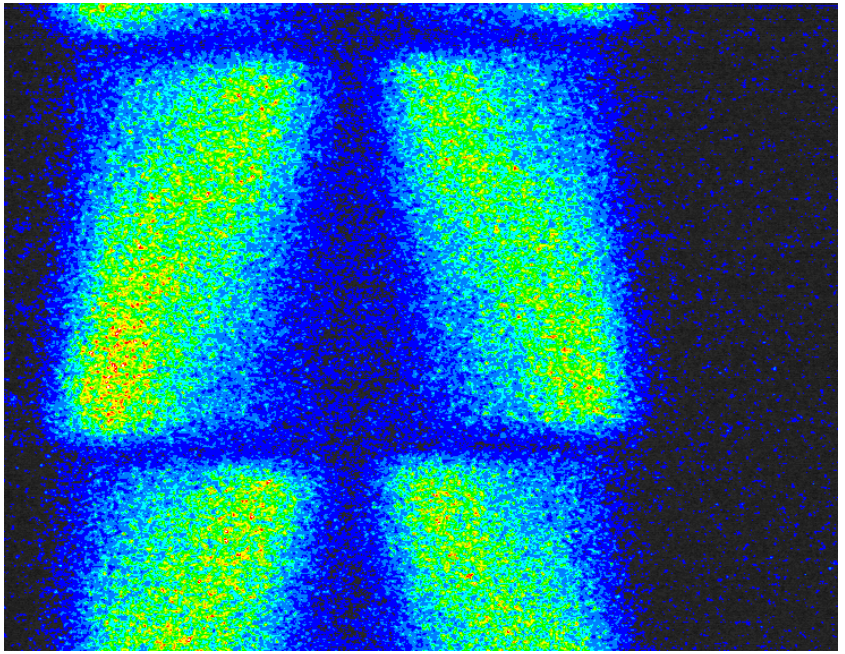
In our experiments we find the maximum lifetime a few kHz beyond the optimum detuning *("low overstretching"* threshold)

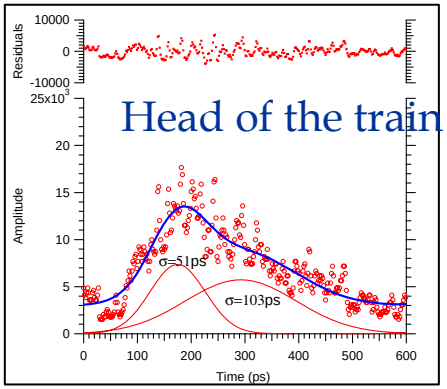
A few kHz beyond this threshold lifetime starts to decay to a few hours and further the beam is lost.

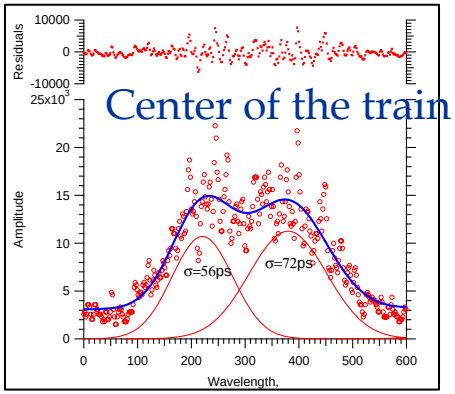
Overstretching in fractional filling

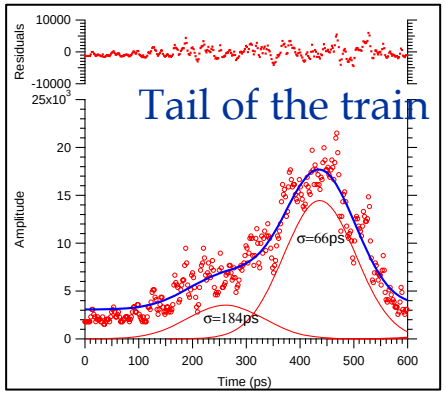
Streak camera image taken for a filling of 96%, at 320mA, with 3HC detuned at **+64kHz**

Entering in overstretching regime the bunch profile is affected by a combination of two effects: the phase shift and the splitting of the particles distribution in two peaks





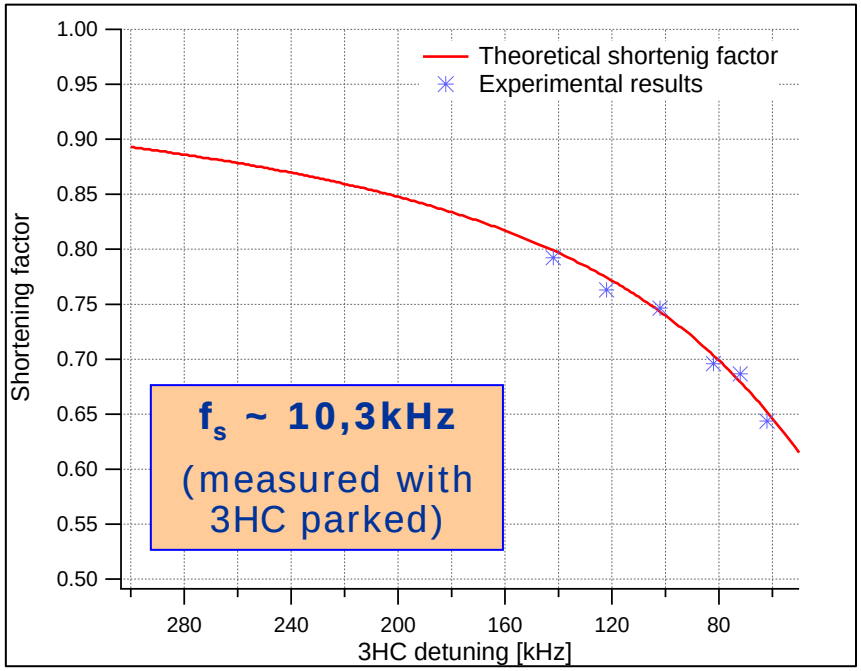




Bunch Shortening Experiments

- Filling set at 96%.
- 3HC tuned at 1498.820Mhz (~ -140kHz) : injection of 320mA and ramping to 2.0GeV;
- Beam stability: longitudinal CBMs are present, so the RMS bunch length measurements results to be very difficult by using the Streak Camera. So we measured the synchrotron frequency increase:

$$f_S \propto \frac{1}{\sigma_b}$$



The minimum detuning reached before losing the beam is –62kHz: at this point the bunch is shortened by a factor **1.6** with respect to the situation with 3HC parked.

Outlook

- 3HC last year operation update:
  - Cryogenic plant reliable, no faults.
  - Injection every 36 hours is now Elettra standard at 2.0 GeV.
  - Gear-boxes are a weak point of the tuning system.
  - The system is efficient even with only one cell in operation.

- A solution for the tuning system MUST be found. *Not easy*.

- Results obtained with the streak camera:
  - Good fitting between our experimental results and the theoretical expectation;
  - In the “low overstretching” regime of the bunch we get the maximum effect on beam lifetime, still keeping the beam quality.
  - Bunch shortening experiments: σ/σ_0 ~ 65%.