Overview of lifetime issues at ESRF

A. Ropert and L. Farvacque

Outline

- ESRF figures
- Key parameters and design strategy
- Review of the different parameters
  - ✓ Correction of errors
  - ✓ Physical aperture
  - ✓ Energy acceptance
  - ✓ Dynamic aperture
  - ✓ Working point

ESRF lifetime figures

Lifetime is an important parameter for :

Users (thermal stability)

Machine physicists (losses and activation, injection efficiency)

Multibunch filling	70 h in uniform at 200 mA coupling: 0.6 % topping-up every 12 h
16-bunch	15 h at 90 mA coupling: 2 % topping-up every 6 h

A.Ropert, ropert@esrf.fr

Key parameters for the lifetime

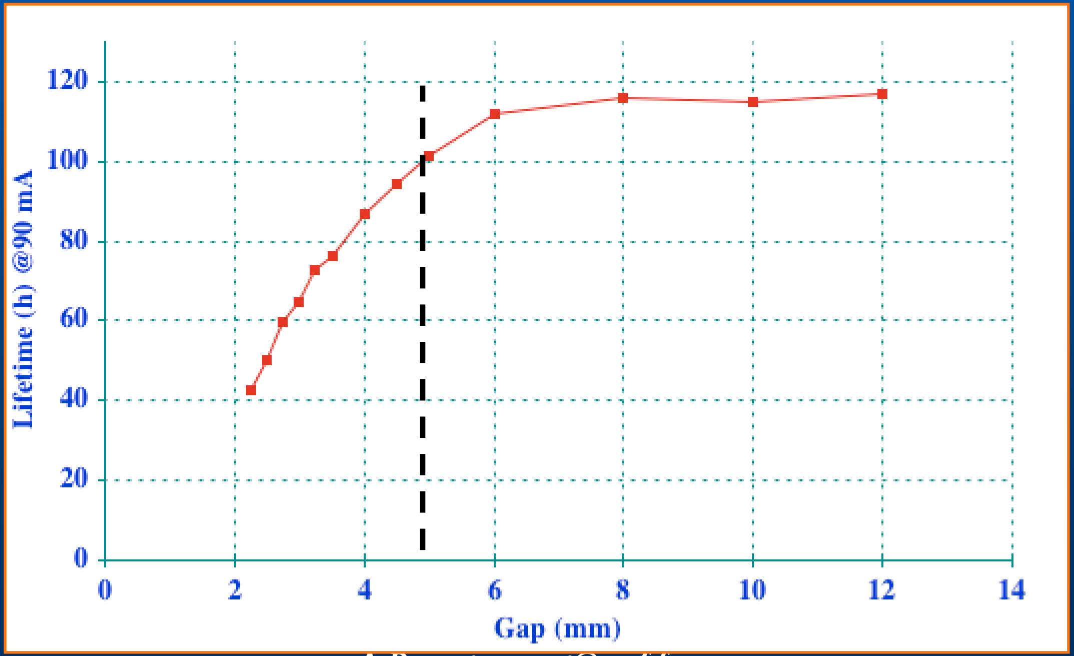
$$\frac{1}{\tau} = \frac{1}{\tau_G} + \frac{1}{\tau_B} + \frac{1}{\tau_T}$$

- Machine energy
- Average pressure and gas composition
- Physical aperture and / or dynamic aperture
- Bunch volume
  - Bunch current
  - Transverse emittances
- Acceptance in energy

A.Ropert, ropert@esrf.fr

Physical aperture

- Septum in the horizontal plane
- Low gap vessels (±4 mm) or in-vacuum undulators in the vertical plane



A.Ropert, ropert@esrf.fr

ESRF

Strategy for achieving the best lifetime

How to achieve the best lifetime when tuning a new lattice?

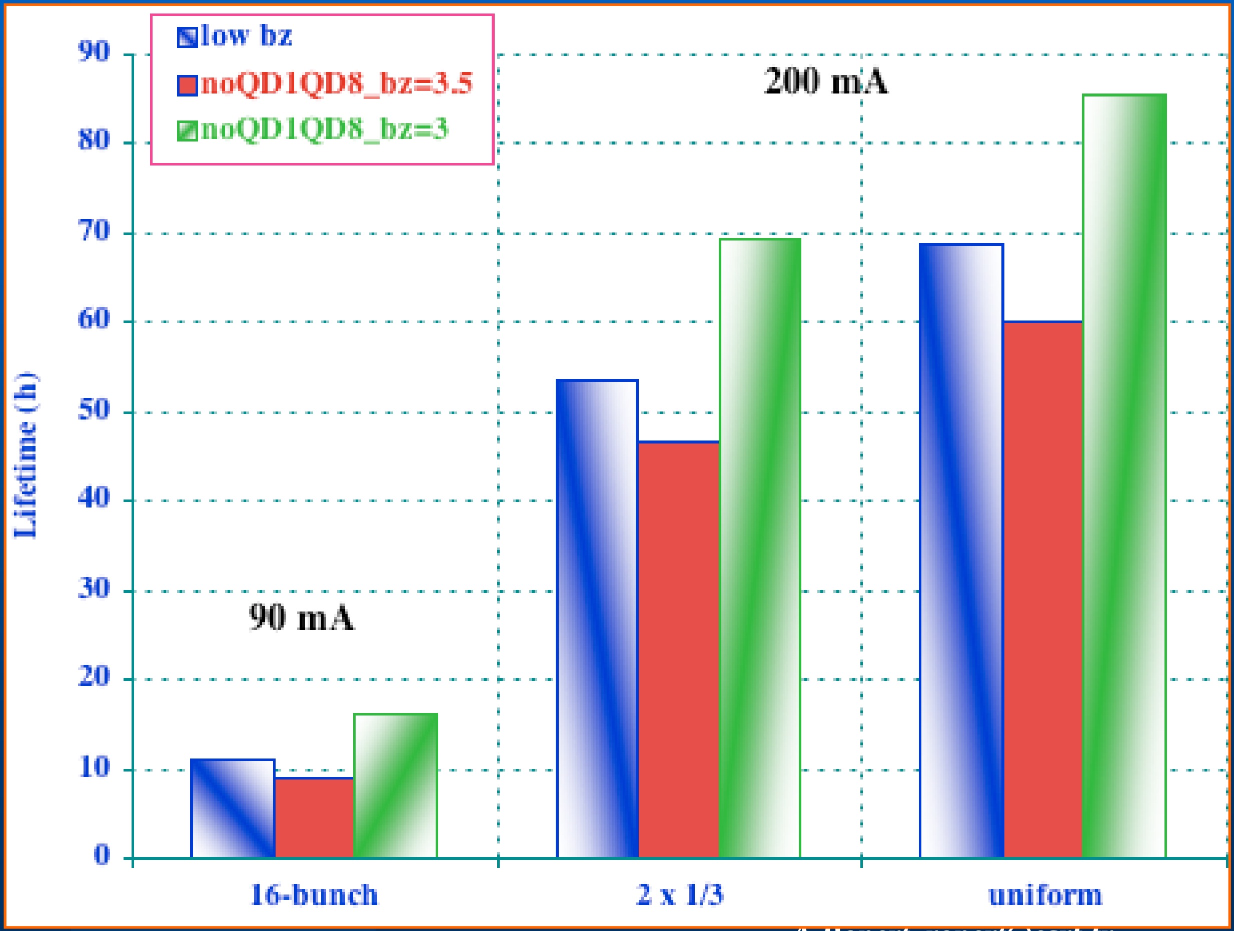
- **Define in simulations the best tuning**
  Working point, harmonic sextupoles, error compensation
- **Characterise expected performances**
  Dynamic aperture, energy acceptance, tune shifts with amplitude and momentum…

What is the relationship between these macroscopic performance characteristics and the lifetime ?

The larger / smaller they are, the longer should be the lifetime

A.Ropert, ropert@esrf.fr

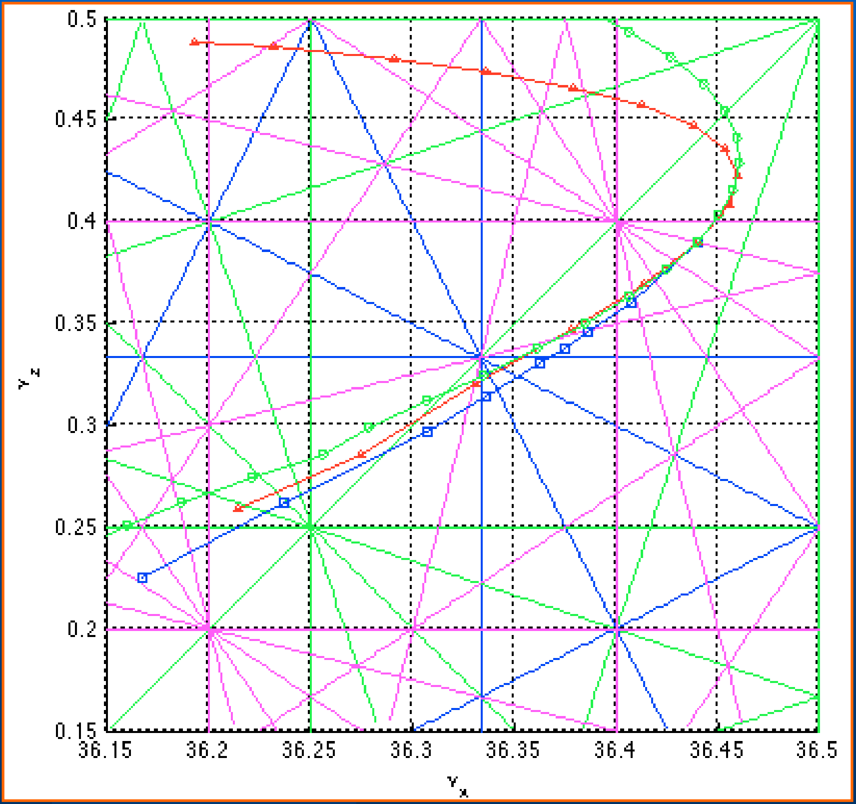
Achieving the best lifetime (1)

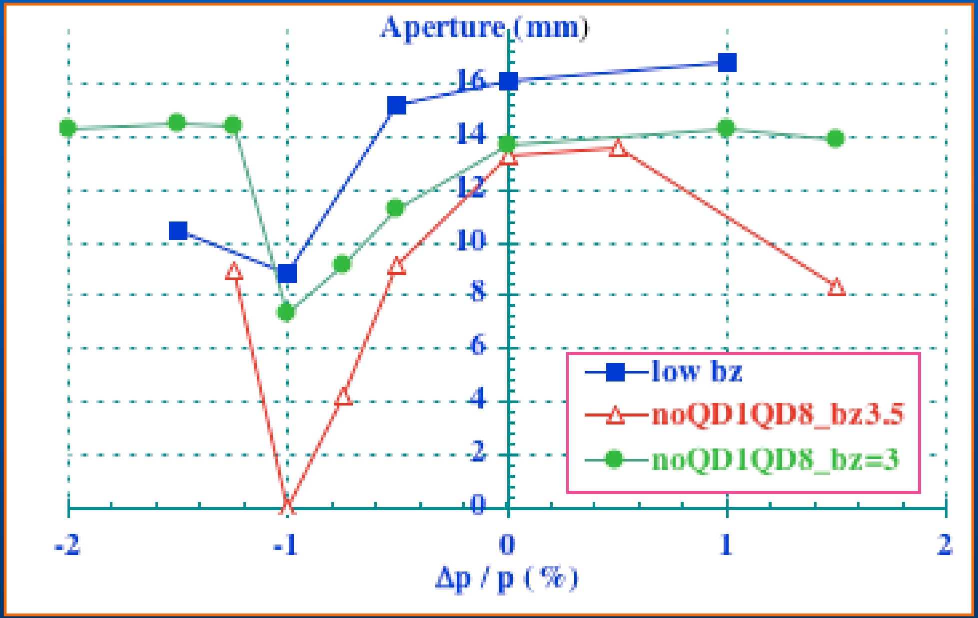


Applying this strategy to different lattices does not give the same results in terms of lifetime !!

A.Ropert, ropert@esrf.fr

Achieving the best lifetime (2)



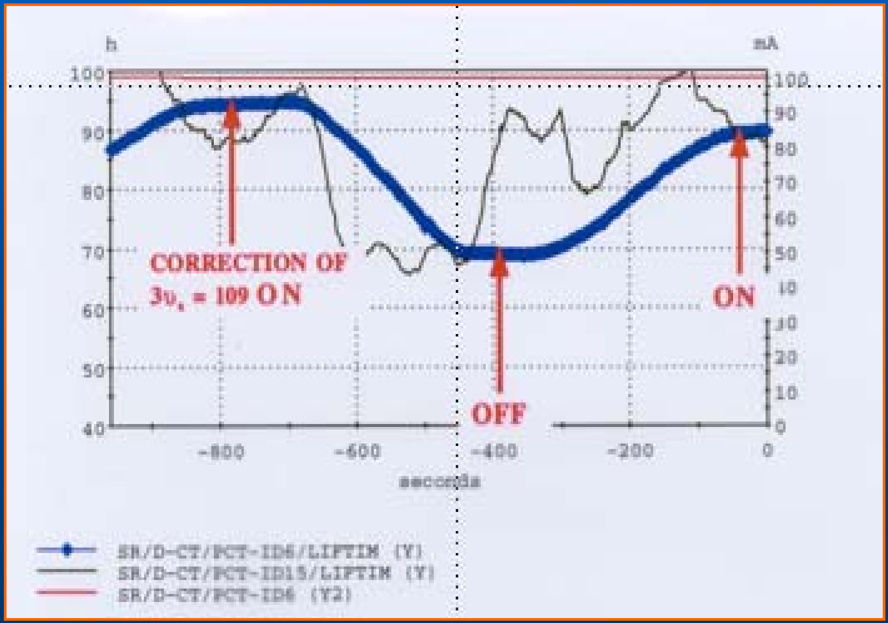


A.Ropert, ropert@esrf.fr

Compensation of errors

Focusing errors

Third-order resonances



A.Ropert, ropert@esrf.fr

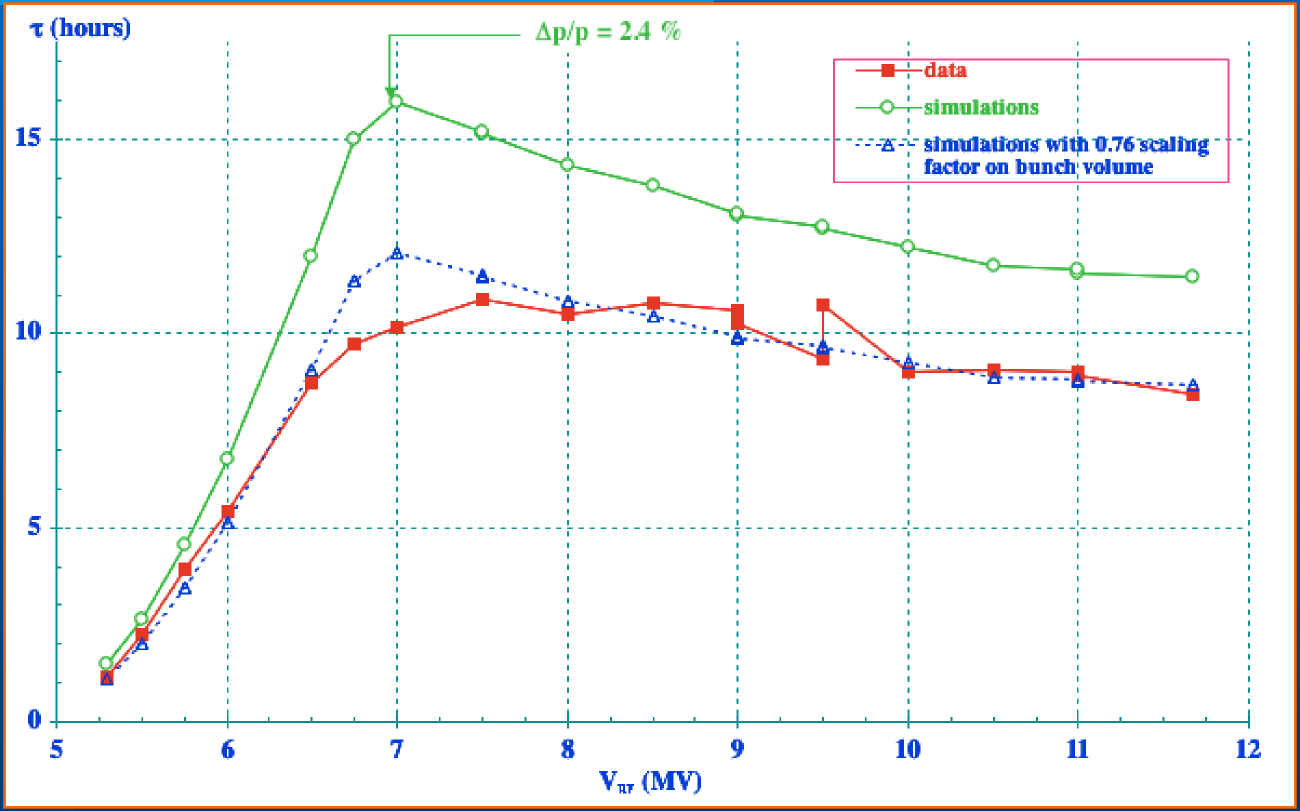
Energy acceptance (1)

Determined by the RF bucket height or by transverse limitations (physical or dynamic)

Measurements

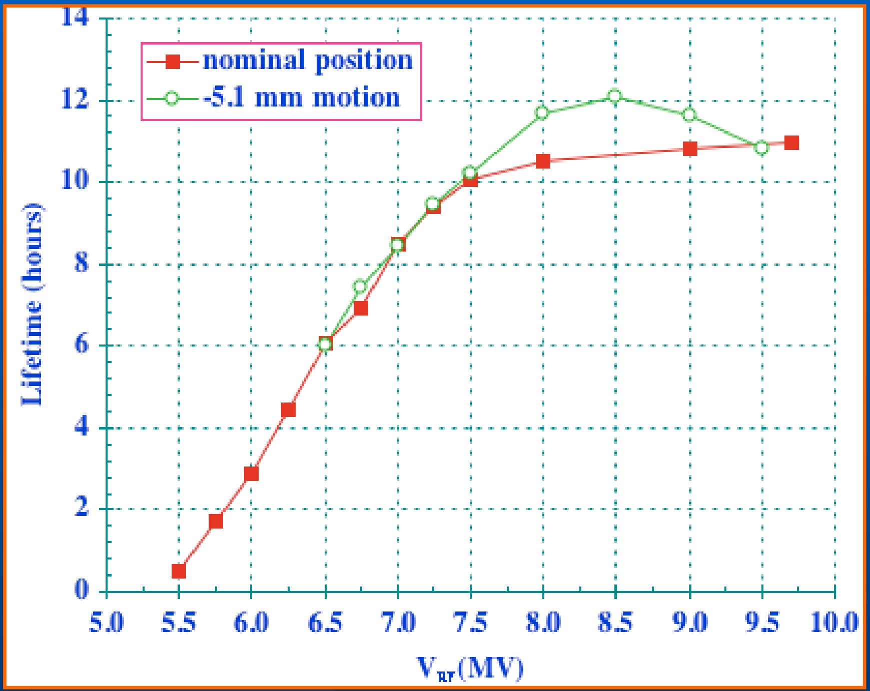
- **Operate the machine in single bunch mode at low coupling**
- **Record the lifetime evolution as a function of the RF voltage**
- **Deduce $\Delta p/p$ from the fit of the experimental data.**

Energy acceptance (2)

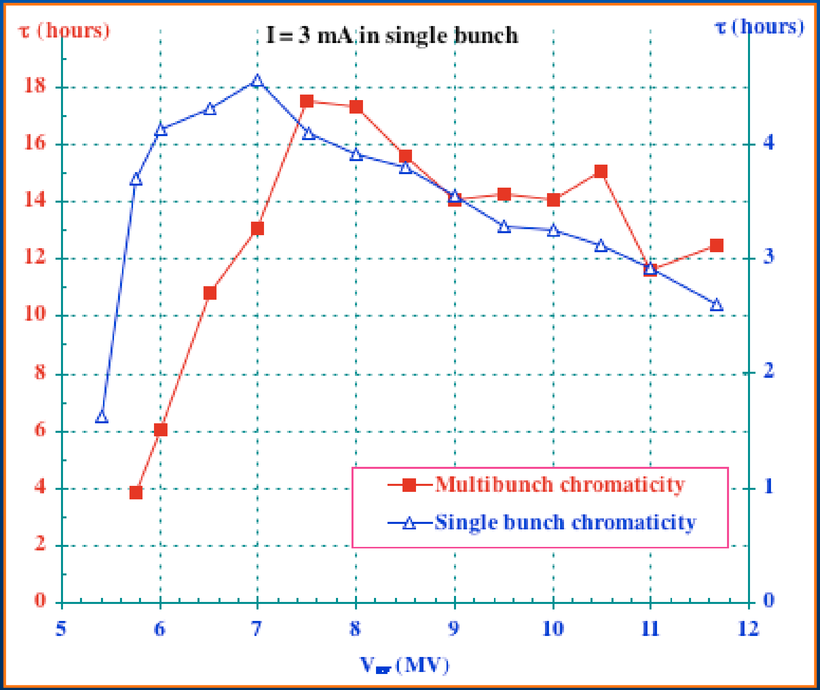


The saturation of the lifetime increase indicates a transverse aperture related limitation

Energy acceptance (3)



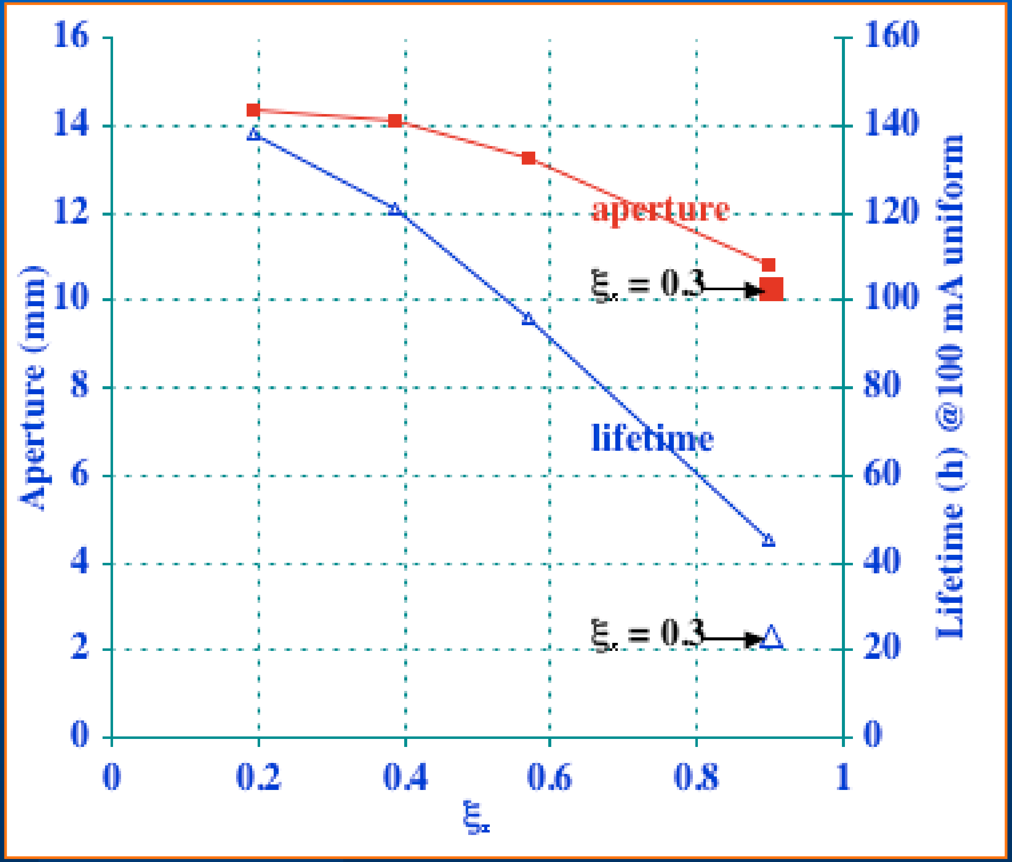
Another measurement in favour of a dynamic aperture limitation



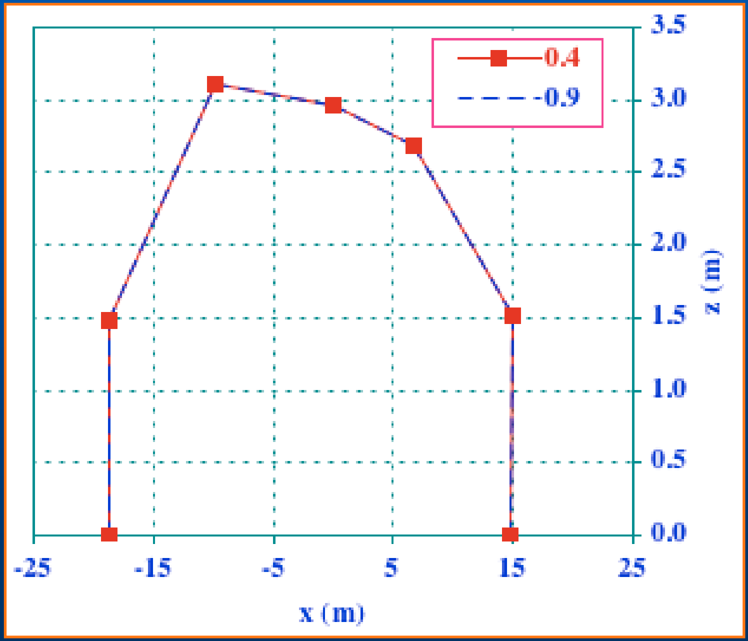
No effect of the septum position ---> dynamic acceptance limitation

A.Ropert, ropert@esrf.fr

Impact of a reduced dynamic aperture (1)



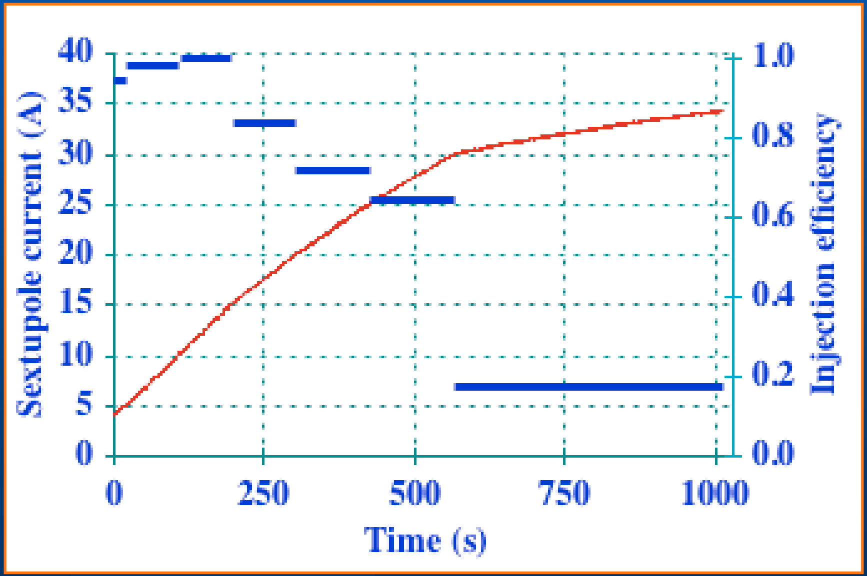
The aperture reduction does not show-up in simulations

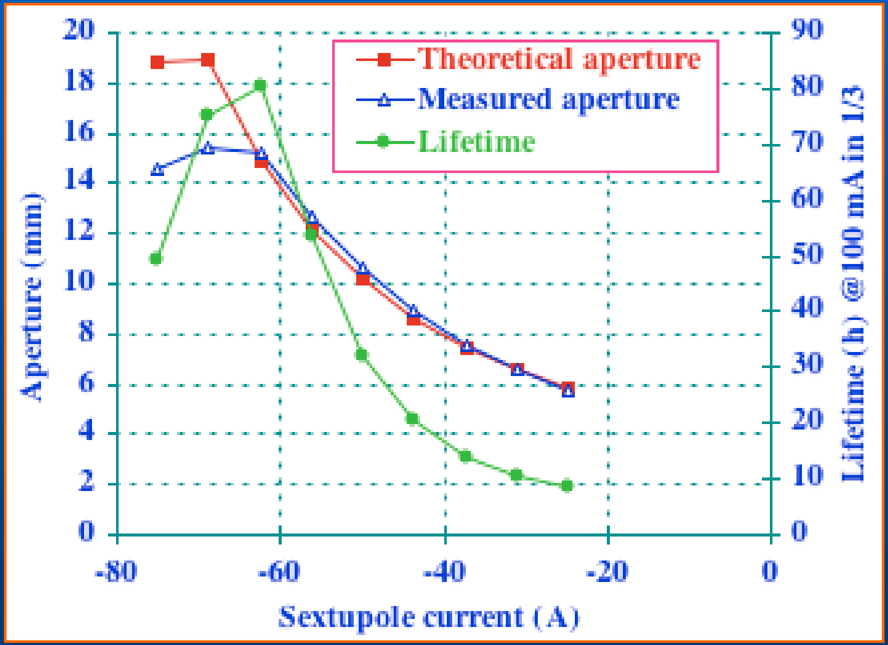


A.Ropert, ropert@esrf.fr

Impact of a reduced dynamic aperture (2)

Scan of one harmonic sextupole family

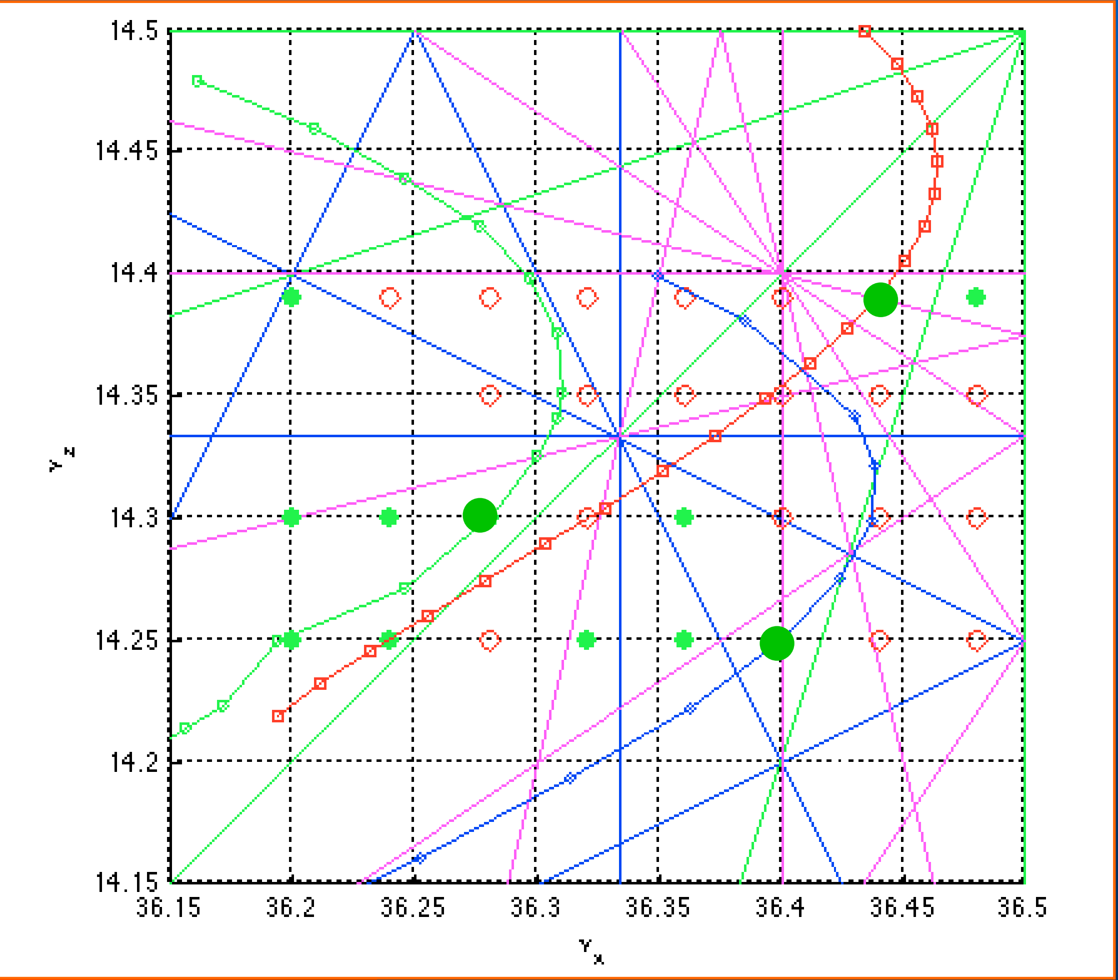




Good correlation between aperture and lifetime reduction

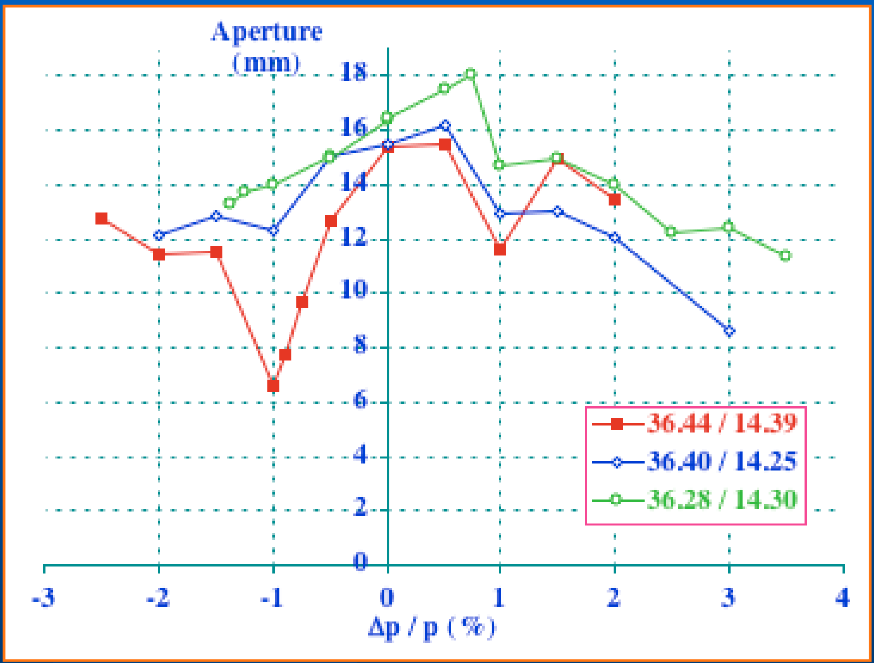
A.Ropert, ropert@esrf.fr

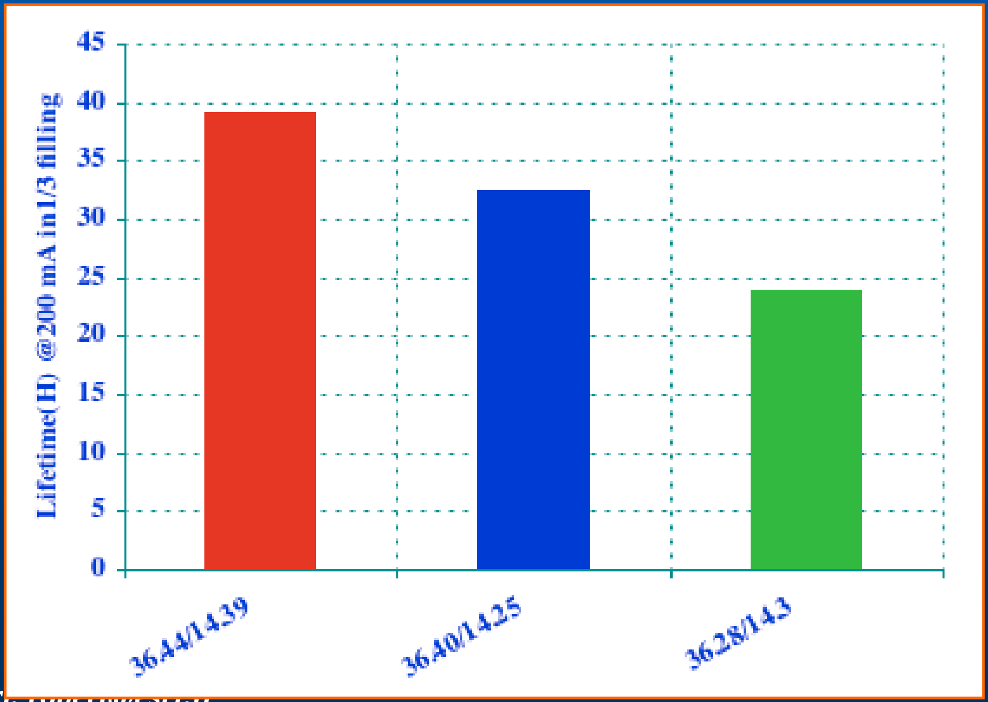
Tune scan (1)



14.5
14.45
14.4
14.35
14.3
14.25
14.2
14.15
36.15
36.2
36.25
36.3
36.35
36.4
36.45
36.5
γ_x
γ_z

Tune scan (2)

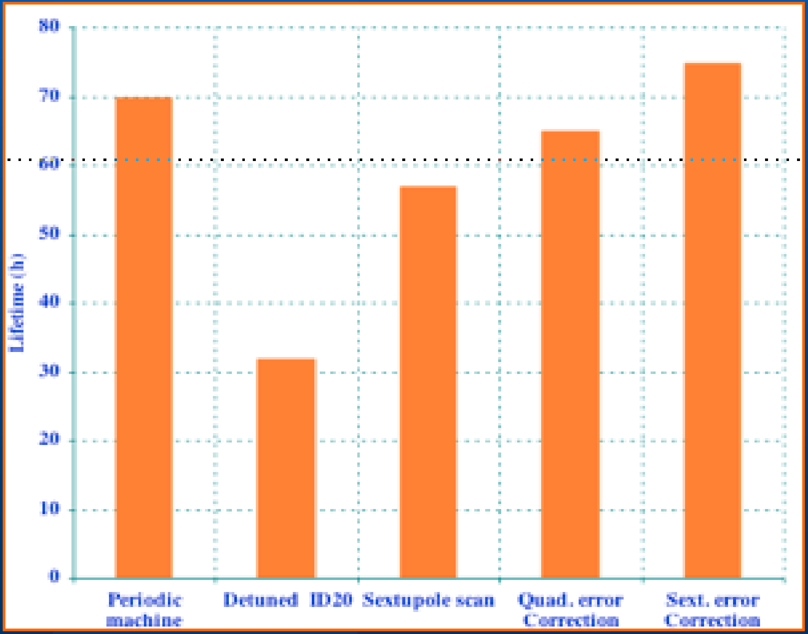


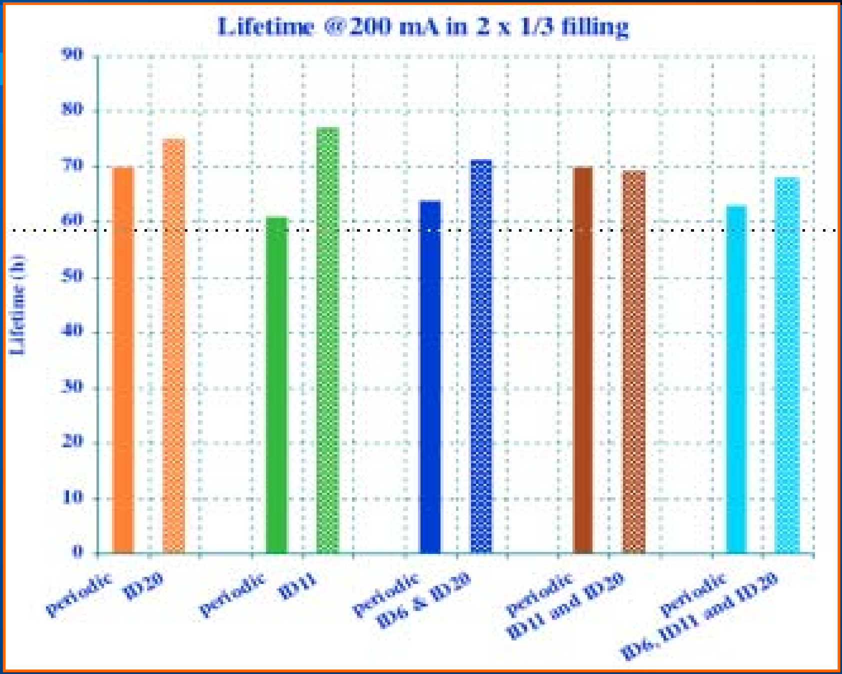


What is the important parameter for the lifetime ?

Detuning of straight sections

In the first instance, detuning has a strong impact





No significant effect of the detuning on the lifetime

Confidence for the future upgrade of straight sections

Conclusions

- It is difficult to identify the key parameter among the various parameters acting on the lifetime

- The correlation between the experimental impact of some parameters and the results from modelling is not obvious

- The severe breaking of the lattice symmetry as induced by the detuning of a straight section has no dramatic effect on the lifetime