Activity Status:

RF Amplitude Modulation at the SPS

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8th August 2003

LCE Section Meeting

Motivation

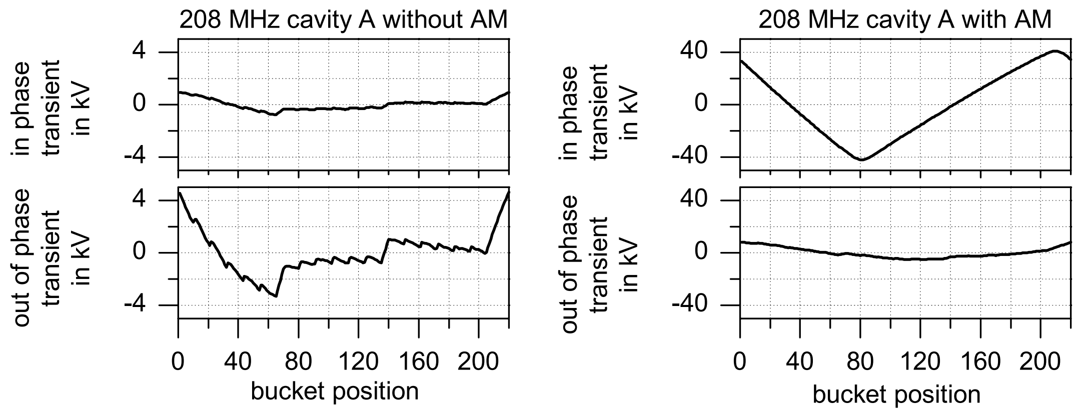
Kicker for the extraction to the LHC becomes too hot due to short bunches.

How to get rid of this effect?

- SPS operates in LHC case with 200 MHz and 800 MHz
- 800 MHz RF system suppresses coupled bunch oscillations
- it is used in the 'bunch shortening mode' BS-mode (both RF systems in phase)
- when we want to use this system in an other way – for example in counter phase – then we have to stabilize the beam again
- one other possibility to stabilize longitudinal coupled bunch oscillations is a RF amplitude modulation – this method works at HERA

RF amplitude Modulation in HERA

IQ-signals of one 208 MHz cavity without and with RF AM at HERA:



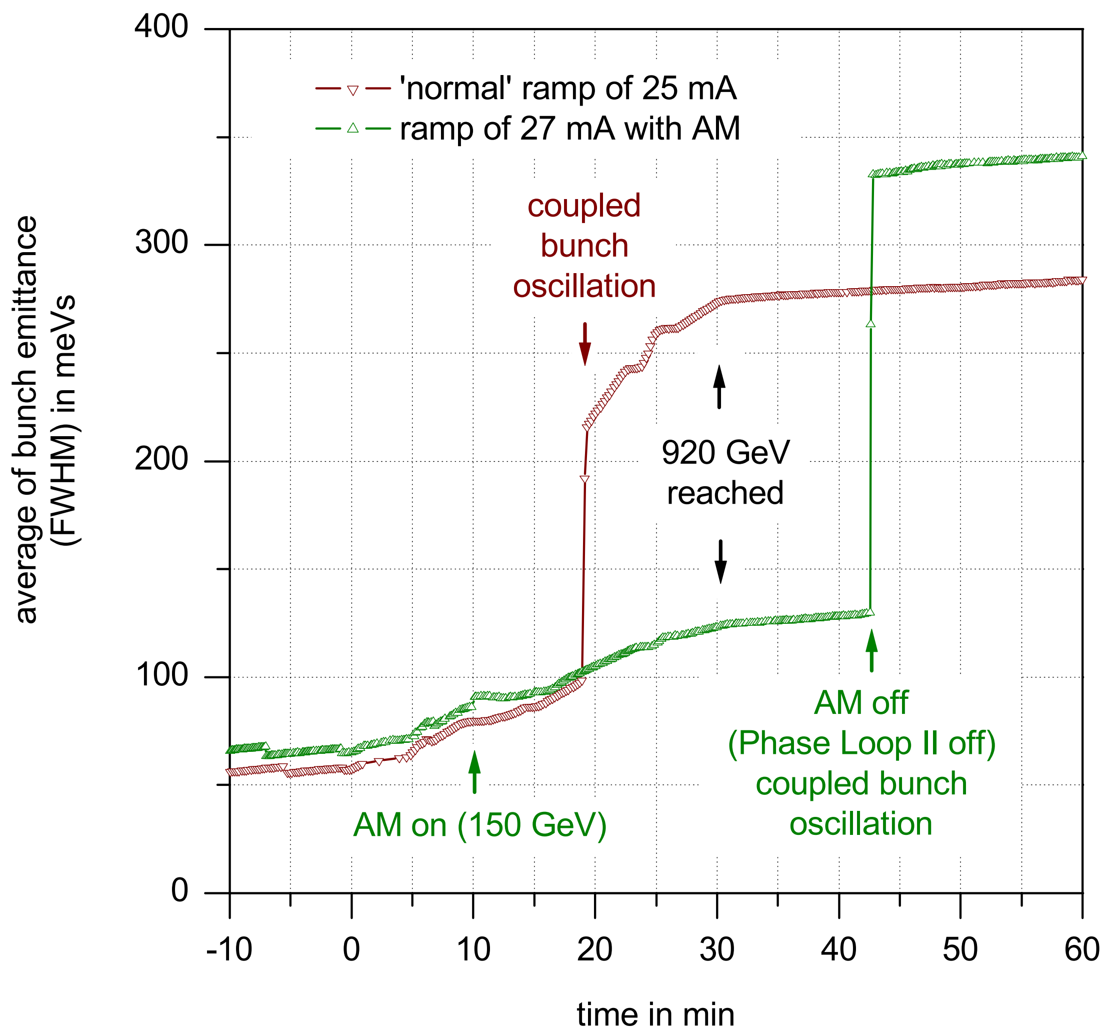
⇒ every bunch positions get its own – but constant – RF amplitude

⇒ every bunch get a individual synchrotron frequency

⇒ chain reaction of bunch to bunch coupling is suppressed

Experience at HERA

Reduction of longitudinal emittance at high energy to 50% of the normal value.
Cross check: After switching the AM off, the beam becomes immediately unstable!



Required information for a test at the SPS

How large is the coupling – respectively the frequency shift $|\Delta\omega_l|$ due to the coupling?

Criterion for the stabilization:

$$\text{coherent frequency spread} > \text{frequency shift}$$
$$S_\omega > |\Delta\omega_l| \qquad \Rightarrow \text{decoupling}$$

Available information form the SPS

- without 800 MHz and additional blow up, the beam becomes unstable at 150 GeV
- bunch length at injection between 3 ns and 3.5 ns
- Energy curve during SPS cycle
- RF curves during SPS cycle

No direct measurement of

- Instability rise times or the frequency shift

⇒ we have to calculate it from the available information

Difficulties for the calculation

- energy gain of SPS is very fast
- about 80 GeV per second
- synchronous phase is about 25 deg

What have I done?

Normally used for full bucket examinations:

$$\varepsilon_{\text{full bucket}}(\phi_s) = \alpha_s(\phi_s)\varepsilon_{\text{full bucket}}(\phi_s = 0)$$

$\alpha_s(\phi_s)$ is stabilized, whereas the values are determined by numerical integration.

In a normal machine, one does not work with 100% full buckets, therefore I extended $\alpha_s(\phi_s)$ for the use of a filling factor:

$$\varepsilon_{\text{full bucket}}(\phi_s, F) = \alpha_s(\phi_s, F)\varepsilon_{\text{full bucket}}(\phi_s = 0, F = 100\%)$$

One can also produce such tables for the

- connection between filling factor, synchronous phase and bunch length
- connection between filling factor, synchronous phase and incoherent frequency spread – here one have to be careful with the integration boundaries

First **very preliminary** result:

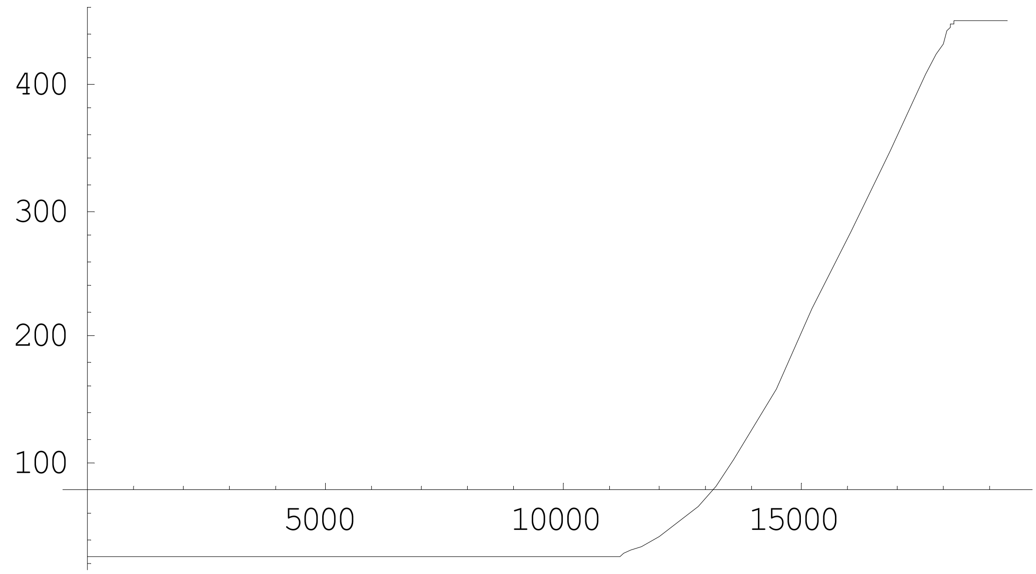
$$S_f \overset{!}{>} 6.5\frac{1}{s}$$

Compare HERA case:

$$S_f \overset{!}{>} 1\frac{1}{s}$$

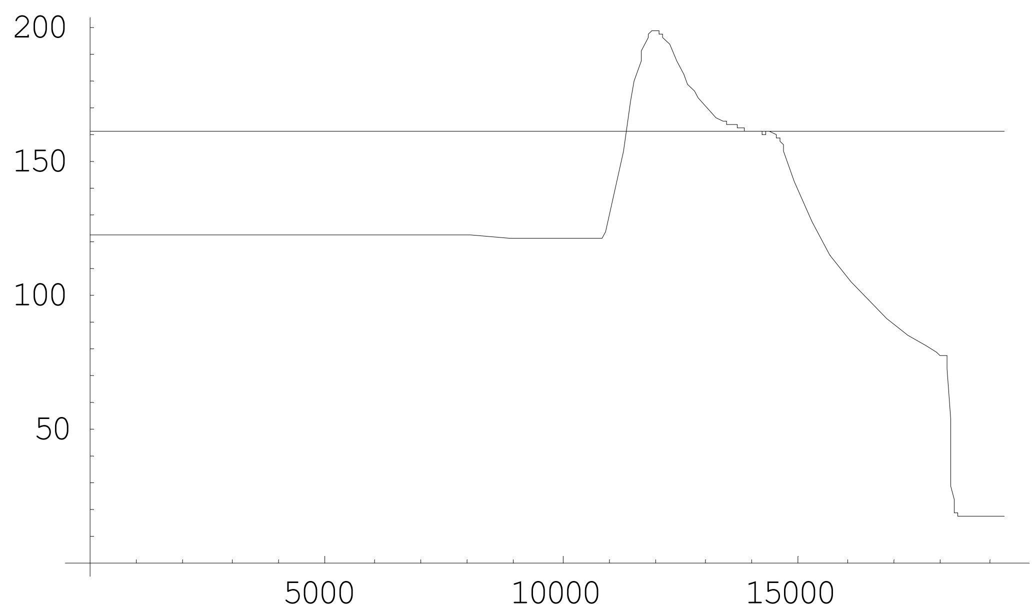
Some Pictures

Energy during a SPS cycle:



(scales: x-axes time in ms, y-axes energy in GeV)

Incoherent frequency spread (s_ω in 1/s) during a SPS cycle:



Bunch length (in s) during a SPS cycle in case of constant emittance (0.5 eVs):