AN OBSERBATION OF THE BUNCH STRUCTURE IN SLOWLY EXTRACTED BEAM SPILL

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Before the extraction of the beam from KEK-PS, the accelerated beam is debunched. And the extraction system starts to extract the beam to experimental area. During extraction, high frequency components of the circulating beam current excite the voltages between the gaps of accelerating cavities. The voltages effect on the growth of bunch structure in the beam.This process is known as the longitudinal instability of the coasting beam, and is obserbed in the rf-structure of slowly extracted beam spill.

The instrument of our obserbation was illustrated in Fig.1. The system displays the time interval histogram of the telescope pulse train. Fig.2 is a typical display in normal machine operation. The histogram on the display is propotional to $\exp[-t/\tau_0]\cdot A(t)$, where τ_0 is a mean time interval of the pulses, and A(t) is the auto-correlation function of the burst. If we assume a sinusoidal ripple on the burst of relative amplitude a, then auto-correlation function will be $A(t)=1+(a^2/2)\cdot\cos(\omega t)$.[1,2]

The modulation of histogram by $(a^2/2)\cdot\cos(\omega t)$ enhances the chance coincidence of experiment. The enhancement of the chance coincidence is regarded as the reduction of spill time. The reduction factor is $1/(1+a^2/2)$, and is called duty factor.

To reduce the rebunching effect of the beam, we tune the resonant frequencies of the cavities nearly $(n+1/2)\omega_r$, where n is an integer, and ω_r is the revolution frequency of the circulating beam. The reason of this adjustment is easily understood by the criterion, given by H.G.Hereward[3], or by E. Keil and W. Schnell[4].

$$\left|\frac{Z}{n}\right| \leqq F\,\frac{m_0 c^2\,\beta^2\,\gamma\,\eta\,(\Delta p/p)^2}{e\,I} \simeq 3.3\ \mathrm{k}\Omega\ ,$$

where Z is the sum of the impedances of the cavities.
n is the harmonic number.
F is a form factor determined by the momentum distribution of circulating beam (~ 1).
$\Delta p/p$ is the fullwidth at half maximum of the momentum distribution($\sim 0.3\%$).
$\eta = 1/\gamma_t^2 - 1/\gamma^2$.
I is the circulating beam current(~ 0.4 A for 3×10^{12} ppp.)

The relations between the impedance of the cavity and the harmonics of revolution frequency in normal operation are shown in Fig. 3.

References

1) D. Bloess et al. " On the measurement of the slow ejected beam structure ", CERN/MPS/SR 69-9.
2) D. Bloess et al. " Measure of the CERN slow ejected beam time structure ", IEEE NS-18 No 3.
3) H. G. Hereward. " Effects of the cavities on debunching ...... ", CERN /MPS /DL 69-7.
4) E. Keil and W. Schnell. " Concerning longitudinal stability in the ISR ", CERN - ISR - TH - RF / 69-48.

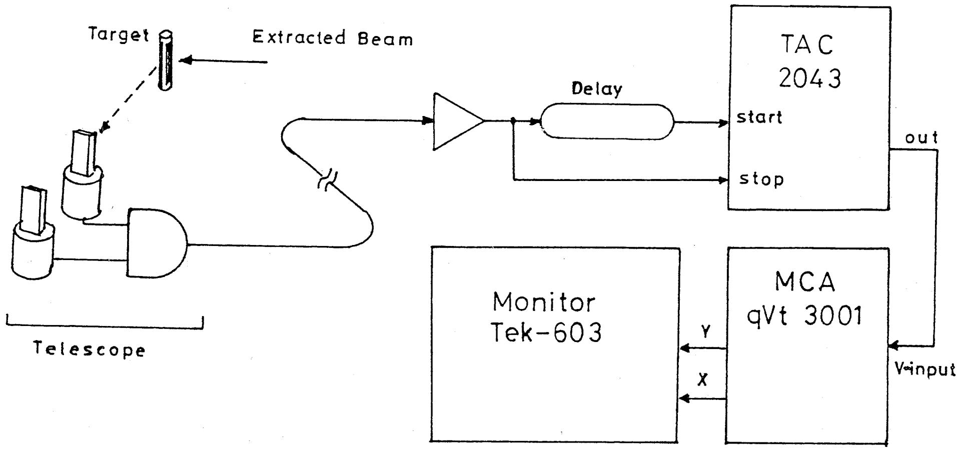

Fig. 1

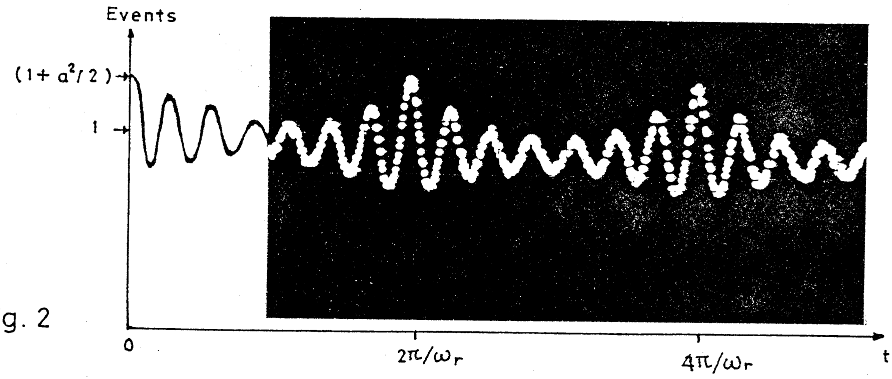

Fig. 2

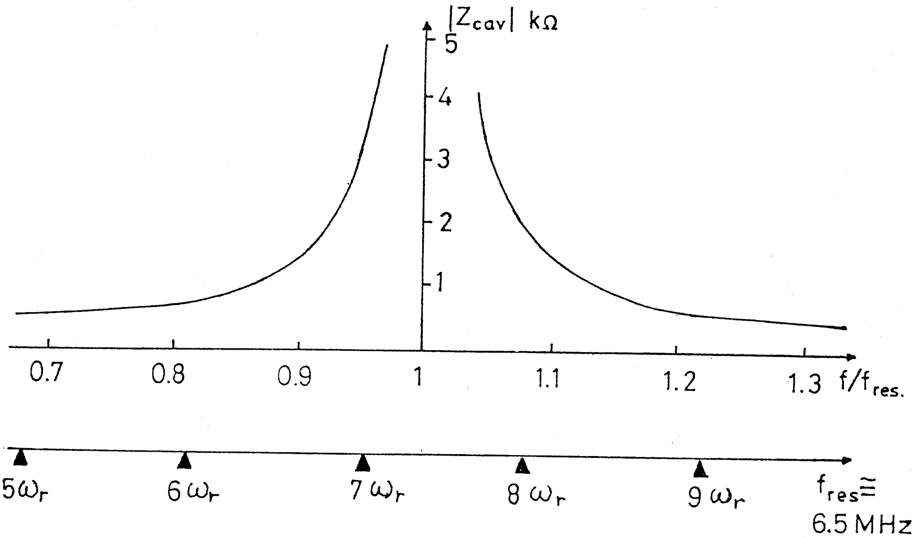

Fig. 3