The Experimental Investigation of the Transient in the Side Coupled Cells Structure

Yu.Senichev
Institute for Nuclear Research of RAS, 60-th October Anniversary prosp., 7a, Moscow
A.Moretti
Fermi National Accelerator Laboratory,P.O.Box 500,MS 341, Batavia, IL 60510
D.Raparia
Superconducting Super Collider Laboratory,2550 Beckleymeade Ave., Dallas, TX 75237

1 INTRODUCTION

The present proton linear accelerator makes it possible to accelerate a beam current of some tens mA in pulse. For compensation of the beam loading effect the generator has to give the additional power. However, this power excites all eigen waveguide modes, and spreads in both direction from the power input, which causes the space-time-dependent perturbations. The magnitude of space perturbations of the electromagnetic field depends on the disperse features of the resonator and has the scale of the cavity length. At the same time the longitudinal oscillation frequency depends on the electromagnetic field amplitude and grows with the rate acceleration. The new tendencies are in terms of the accelerating rate increasing and using a more powerful generator to drive more long resonators. Increasing the accelerating rate and cavity length significantly increases the probability of the parametric resonances in the longitudinal motion. These resonances even at a relatively small amplitude of perturbation 2-5% can destroy the separatrix. When increasing the accelerating rate and decreasing resonator length, the order of synchro-betatron resonance falls, so the longitudinal oscillations can influence transverse motion and emittance growth.

2 EXPERIMENT STATEMENT

This effect has been studied theoretically in work [1]. However, taking into account the importance of conclusions for high intensive proton beam accelerator, we have done the experimental measurements on FNAL linac, as example, for investigation this effect in details. Transients can be caused not only by the beam switching on or off, but also by the feedback system, that has a high coefficient of stabilization. The suppressing of any amplitude of phase random instability by feedback system leads to the input of corrected power, which causes the space distortion of the electromagnetic field. Since the FNAL linac in the summer 1992 was under the tuning, we have done measurement of the electromagnetic field distortion, which was called by switching off and on generator. For getting more exact picture and checking of results we used two pulses with different amplitude. The figure 1 shows the common scheme of measurement. Each module consists of 4 tanks. The tank is formed by brazing together 16 identical accelerating cells and almost same identical coupling cells with 5coupling coefficient. The tanks are connected with bridge couplers. The power from the generator is input into the central bridge. Five loops were installed in the testing module in five points 1, 2, 3, 4 and 5. The loops 1, 2 and 3, 4 are radiotechnically symmetrical. The loop 5 was used for measurement of the reflective signal on the input in module. Figure 2 shows two pulses, which we could observe in cavity. The time scale and amplitude scale are $20\mu s$/div and $0.5V$/div correspondingly. The shape of pulse practically don't depend on the point of measurement. The second pulse switch on with $40\mu s$ delay relatively by first pulse after stabilizing of transient. In the experiment we had the possibility to measure

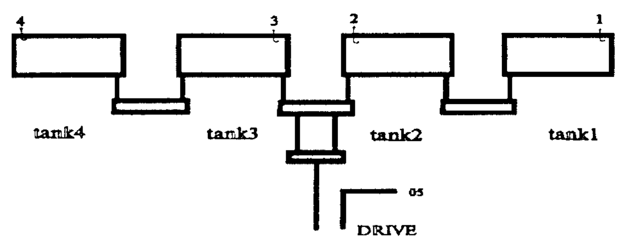

Figure 1: The scheme of measurement

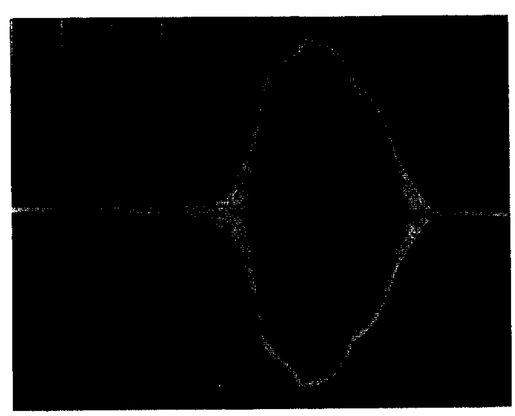

Figure 2: The RF pulses in cavity

simultaneously in all five points and to observe the process in the real time and in the real space. What do we expect? Figure 3 shows the theoretical results, what will happen in cavity during injection of the beam and simultaneous input of power.

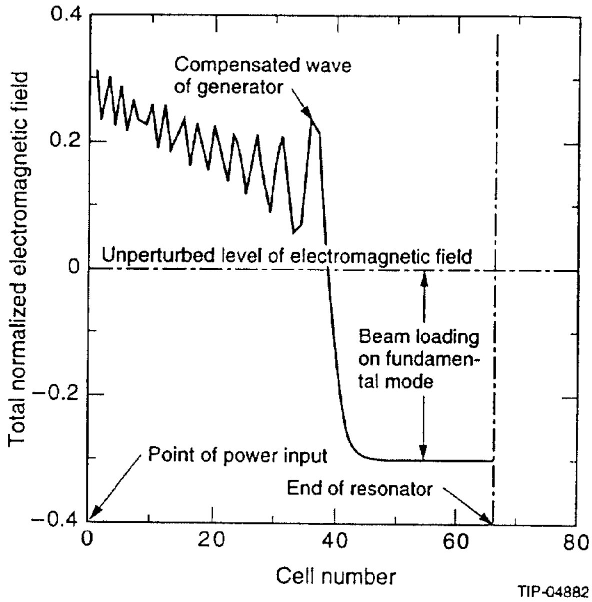

Figure 3: The perturbed electromagnetic field in cavity(calculation)

Figure 4 shows the experimental measurement of field in two points, loops 1 and 2. The character of two curves on figure 4 is very similar each to other. The time shift

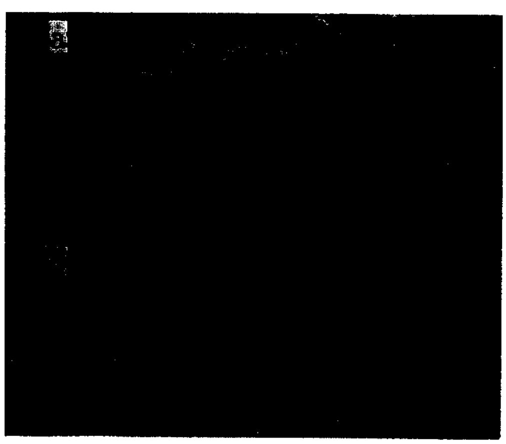

Figure 4: The experimental measurement of RF field in loop 1 (a) and loop 2 (b)

between two curves equals 0.5 μs , what equals to the propagation time of energy along the cavity. The similar behavior says, that the compensated accelerating structure behave itself in transient, as the cavity with the length equal to the part of the cavity filled by energy. The front of the wave can have significant impact. In our case we have the front of wave about 20%, if to take the steady level by the 100%. The oscillation of the amplitude during the pulse shows, that the nearest not fundamental mode prevail over others not fundamental modes. In order to except the average level of the pulse we have done measurement the different signal from loop 1 and 2 (fig.5). The value of the nearest excited mode amplitude exactly

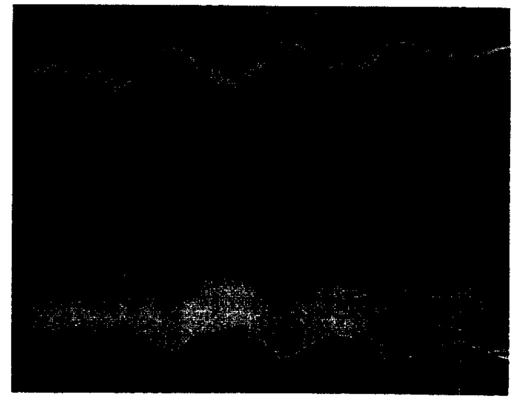

Figure 5: The different signal from loop 1 and 2

equals our calculation [1] and accords to our model and understanding. Besides, we can recognize this mode by the oscillation frequency of amplitude.

3 CONCLUSION

We have done measurements of the transient in structure CCL of FNAL for testing of our understanding, what will happen in cavity during injection of the beam. The amplitude of the electromagnetic field distortion can reach 10characteristic time $\frac{2Q}{\omega}$. It means the time- space distortion of the electromagnetic field in case the parametric resonance with the longitudinal motion can cause the strong instability of beam and losses.

4 ACKNOWLEDGEMENT

We would like to express our thanks to Dr. W. Funk and Dr. C.Schmidt for their help and support in this work.

5 REFERENCES

[1] Yu.Senichev, Transient Effect in High Intensity Proton Linear Accelerator, SSCL-641, 1993.