Experiment: Vertical Resistive Wall Transverse Instability at 1855 kHz Stack Frequency (unbunched proton beam)

Date of Experiment: 28 October 1981

Experimenters: F. Pedersen and A. Poncet

1. Introduction

First signs of a vertical transverse instability on a 8E10 $\bar{p}$ stack, unbunched, occurred on October 7th, while waiting for SPS readiness. A change of ΔQ_V = .002 seemed to improve stability.

2. Vertical beam transfer function measurements

These were done at 1855 kHz, with a reverse proton beam of 2 to 8 * 10^{10} p's, with the signal from the V_β Schottky PU on Lars Thorndahl's Network Analyser. Results are shown on the attached sheets (Fig. 1), which also show the tune of the machine for that experiment (Fig. 2).

The first 10 modes (N = 1 to 10) were recorded for the slow wave, of which 2 (modes 5 and 6) were found unstable at these beam intensities.

3. Vertical transverse instability of the stack at 5.065 MHz (Mode 5) and 6.9377 MHz (Mode 6)

Excitation of the beam from a swept frequency of the network analyser via the vertical damper electrodes around these two frequencies provoked the onset of the instability. Although the exact kinetics of these instabilities has not been recorded, growth and decay times were in the range 10 to 20 secs, with fast initial growth rate, stabilisation of wave amplitudes at a few millimetres (measured with scraper) for periods which could reach a few minutes (photo No. 8 illustrates this).

4. Damping of the instability with the transverse feedback kicker

Photos 11 and 12 show the amplitude decay of the "standing wave" as one switched on the vertical transverse feedback loop.

Best delay with reverse protons was found to be 163 ns, giving a damping time of $\sim$ .5 sec on mode 5 with no attenuation on the amplifier.

Using the network analyser, the delay was then adjusted in the case of $\bar{p}$'s so as to get a flat phase response for all frequencies up to mode 10, and found to be best at 206 ns (horizontal) and 198 ns (vertical).

On November 5th, with a 1.43×10^{11} $\bar{p}$ stack waiting to be transferred to the SPS, the growth of the $6\text{-}Q_V$ line was observed with dampers off (this at that time being necessary for $\bar{p}$ ejection) with a growth time of 31.4 ms. Switching on of the damper cancelled it (photo 15, Fig. 2).

5. Conclusions

No evidence for this instability has been found since then and transverse feedback dampers are doing their job. More measurements are necessary to better understand the exact mechanism.

Reported by: A. Poncet

Figure 2

⑧ Q measurement

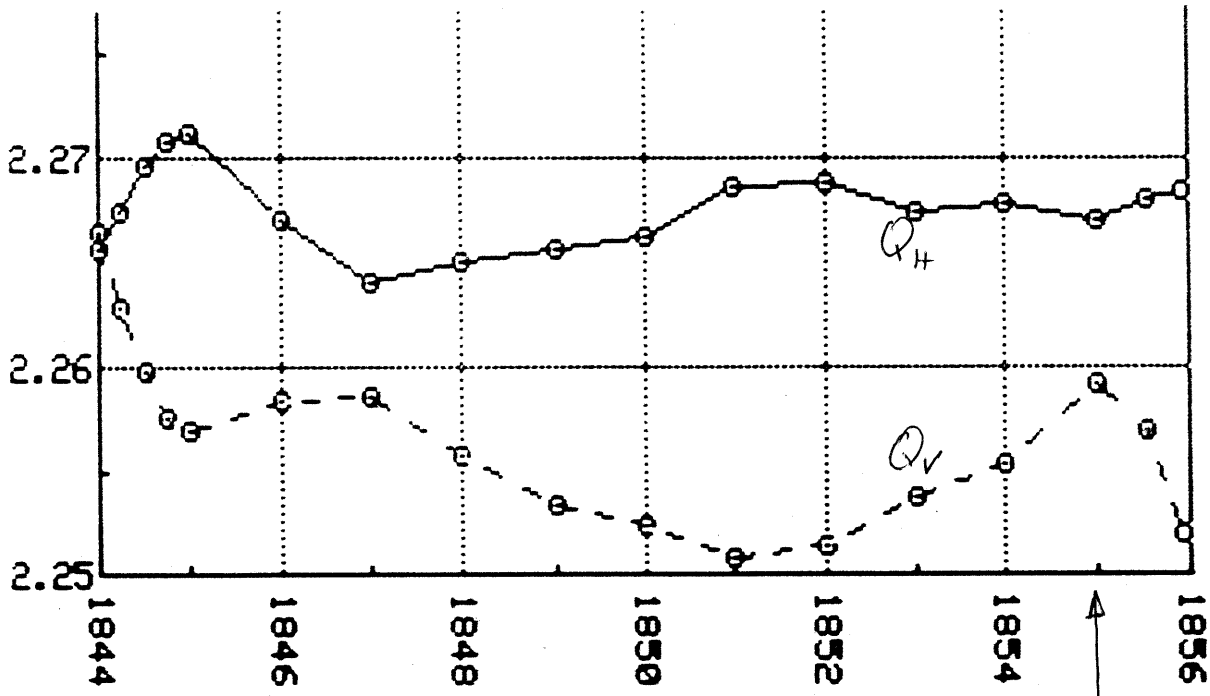
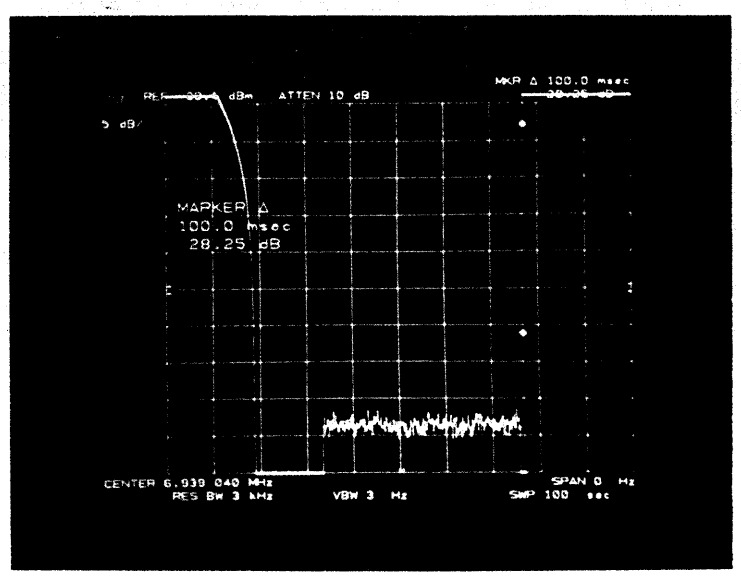


photo 15:



Schottky PU V, non-resonant

6-Qv line before, during and after vertical damper opt.

N = 1.4305 x 10^11

1)

2) switched off (lowers noise level)

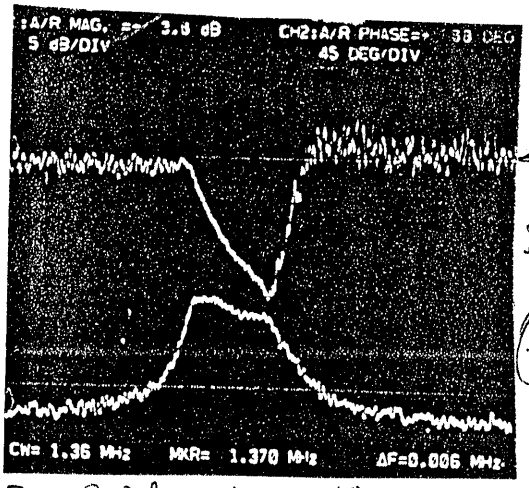
3) $T = 31.4$ ms! growth of 6-Qv line (no losses)

4) mode stabilizes itself (beam blown up)

Figure 1 :

UNBUNCHED ϕ BEAM VERTICAL BTF AT 1855 KHz

(Number of ps = 2 to 8×10^{10})

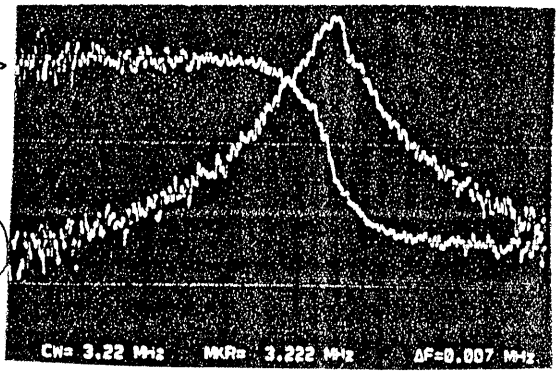


phase uncorrected for cable length.

1

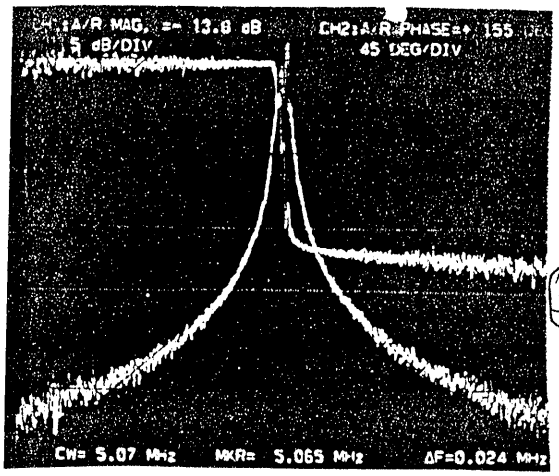
4-Q_V →

Stable



2

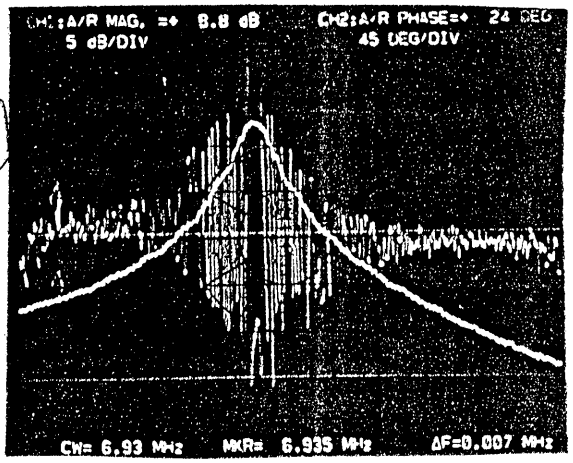
3-Q_V f_r : 1.3727 MHz STABLE



5-Q_V

UNSTABLE ←

3



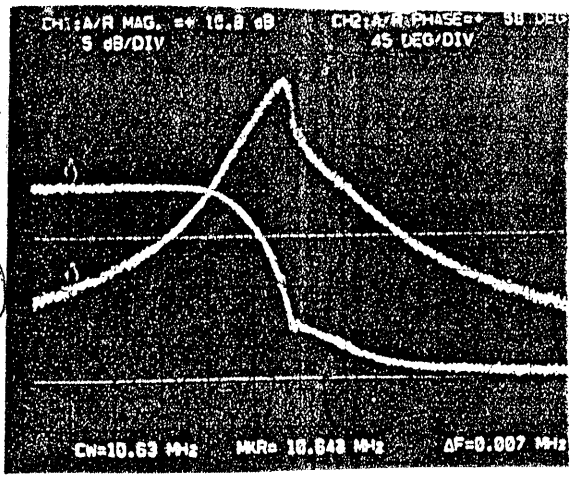
4

6-Q_V

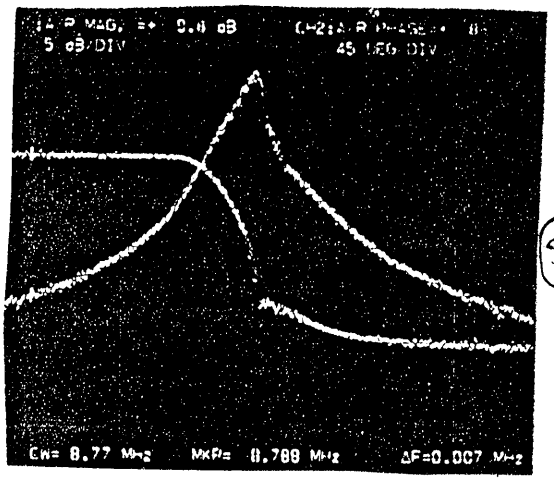
UNSTABLE →

8-Q_V

STABLE →



6



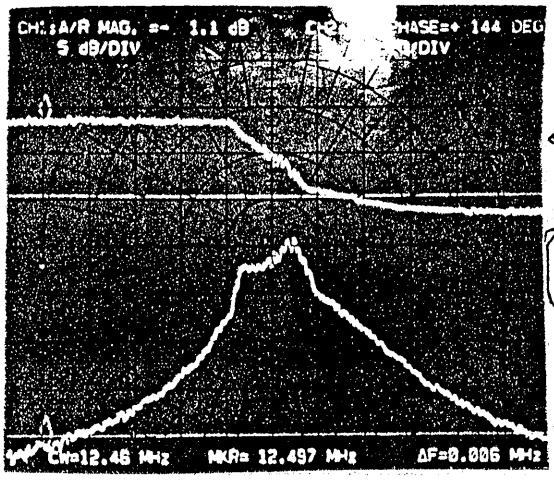
7-Q_V

STABLE ←

5

9-Q_V

STABLE ←



7

"MECHANISM" OF INSTABILITY ON MODE 6 :

(10 minutes duration)

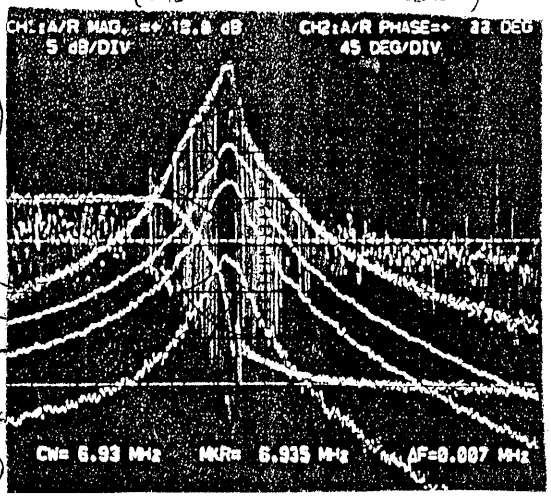
8

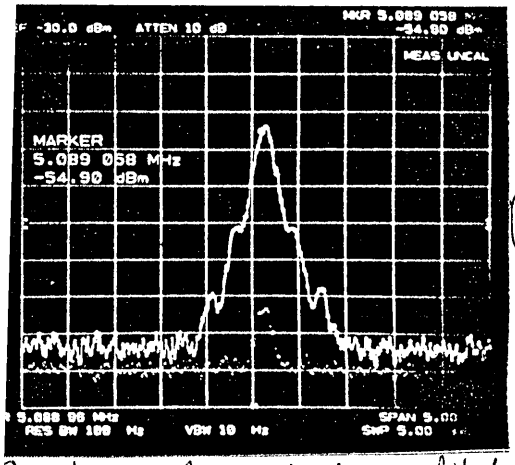
60 sec

15 sec

10 sec

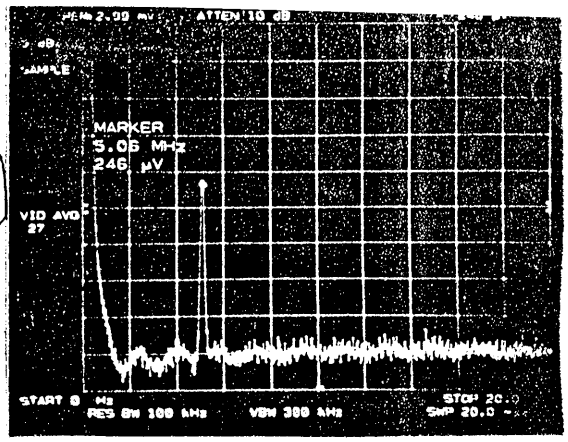
TIME 0 sec (after excitation)





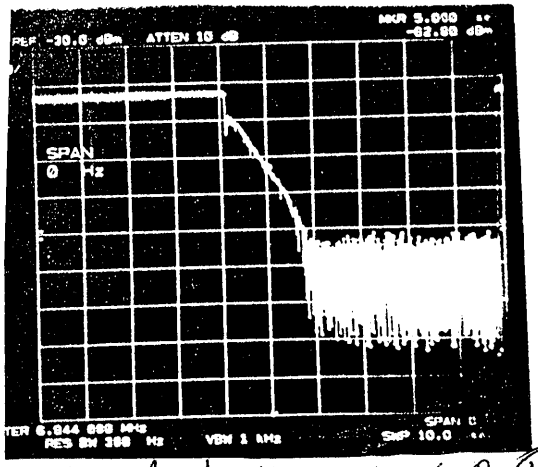
(9)

Spectrum of constant amplitude vertical standing wave (5-Q_V) shows Main Powers supply's modulation of the Beam and ratio of PU BLG11 (faint) and schottky signal.



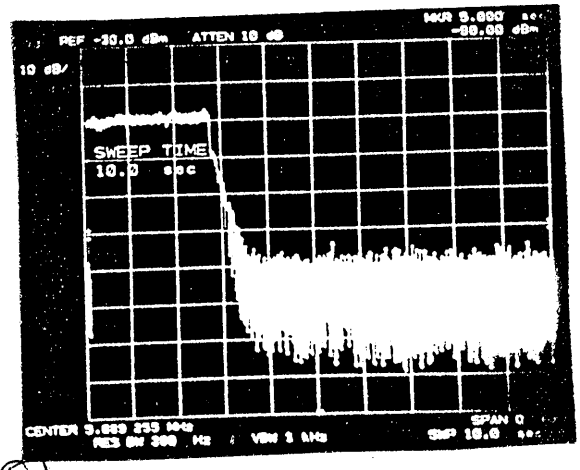
(10)

V_p Schottky PU response at low frequency is very good for mode 6 standing wave.



(11)

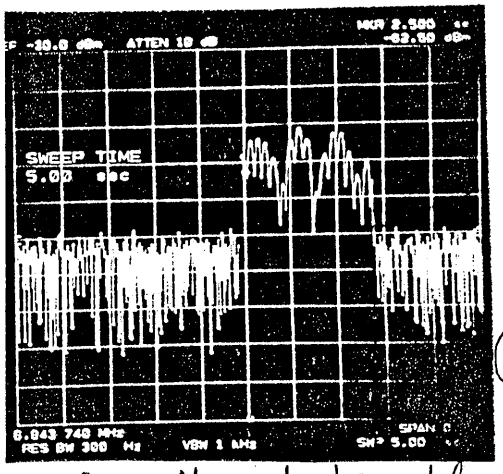
Damping of standing wave 6-Q_V with initial (as found) delay of 189 ms & transverse feed back kicker. 0dB. Damping time ≈ 1.5 sec



(12)

Same thing on mode 5-Q_V but damping time of .5 sec.

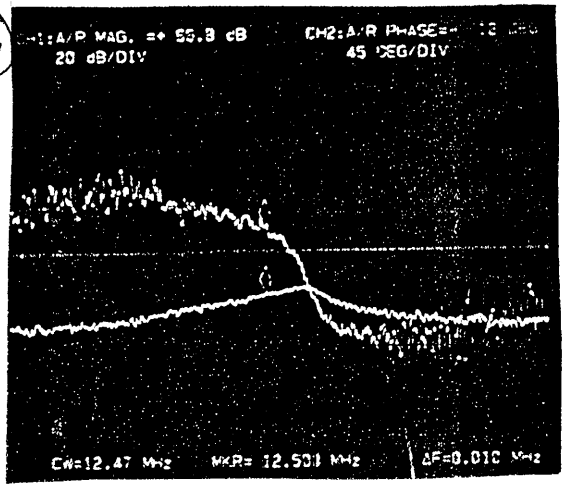
difference in damping time at these 2 frequencies indicates that delay between PU and damper of 189 ms was misadjusted



(13)

5-Q_V after adjusting delay at 163 ms. Very short damping time.

DELAY WAS THEN CALCULATED TO BE 206 ns (Horizontal) and 198 ns (Vertical) FOR ANTIPROTONS AND CHECKED TO BE CORRECT WITH A 6×10^9 $\bar{P}$ stack.



(14)

10-Q_V Line —

Phase looks Flat within ± 20°