SPS-DI/EJNW/nh

13.6.77

Mlle Susan LEECH/Bib/SPS Commissioning = 2 ex.

SPS COMMISSIONING REPORT NO. 63

Experiment : 10^{13} with an Intermediate Flat Top

Date : 20th May, 1977

Experimenters : M. Cornacchia, P. Faugeras, R. Linnecar, R. Lauckner, A. Millich, W. Mills, J-C. Soulie, E.J.N. Wilson

1. Aim of Experiment

In the past, two batch injection from the CPS has yielded 10^{13} protons at 400 GeV but with a simple 400 GeV ramp which bears little resemblance to that now used operationally. In this experiment, intended to pave the way for using two batch injection as part of regular operation we used a cycle with a 200 GeV intermediate flat top, the present operational Q value of 26.6 and with the rate of rise chosen to maintain constant bucket area. We hoped to identify the origin of the large losses in the early part of the cycle which have plagued previous high intensity runs.

2. Machine Tuning for Double Injection

The operations crew set up the machine paying special attention to the following points :

a) No r.f. radial bumps were used.

b) The capture frequency was adjusted to match that of the incoming beam.

c) The slope of the MB power supply trim was adjusted after measuring the change in revolution frequency of the captured beam along the injection platform.

d) A single r.f. radial pick-up at position 312 was used and a beam bump adjusted at this location to minimise the capture transient on the radial loop signal.

e) A new automatic Q correction program was used to trim Q over the whole cycle.

We found that, as in previous runs, more beam is accelerated if the first CPS batch is left to coast without r.f. and adiabatic capture is applied only once when both batches are in. It may be that performing r.f. capture twice on the first batch increases the momentum spread to the point where beam is lost to stopbands later in the cycle. Only a small fraction (10%) of the first batch spreads into the empty half of the machine, to be kicked out as the second batch is inflected. Provided the r.f. capture frequency is well adjusted the lack of synchronism between the second batch and the hole in the circulating beam is acceptable.

Once set up, the machine remained stable for many hours accelerating more than 9×10^{12} and at best 1.014×10^{13}. Slow extraction experts succeeded in fast ejecting 10^{13} protons at 200 GeV though reacceleration of this intensity to 400 GeV is still accompanied by emittance blow up preventing extraction at 400 GeV.

3. CPS Intensity

It has been suggested that double batch injection of a somewhat reduced CPS intensity provides a more stable means of sustaining intensities approaching 10^{13} protons. We found that reducing the injected intensity per batch from 9×10^{12} to 7×10^{12} improved pulse to pulse stability and still gave 9.5×10^{12} at 400 GeV.

4. Beam Loss and Transverse Effects

For the first time the high intensity conditions remained stable for many hours, long enough to make systematic observations of beam loss. The main loss occurs about 60 ms after transition. Figure 1 shows a rather severe manifestation. It is this loss which on previous runs has often caused more than half the injected beam to disappear.

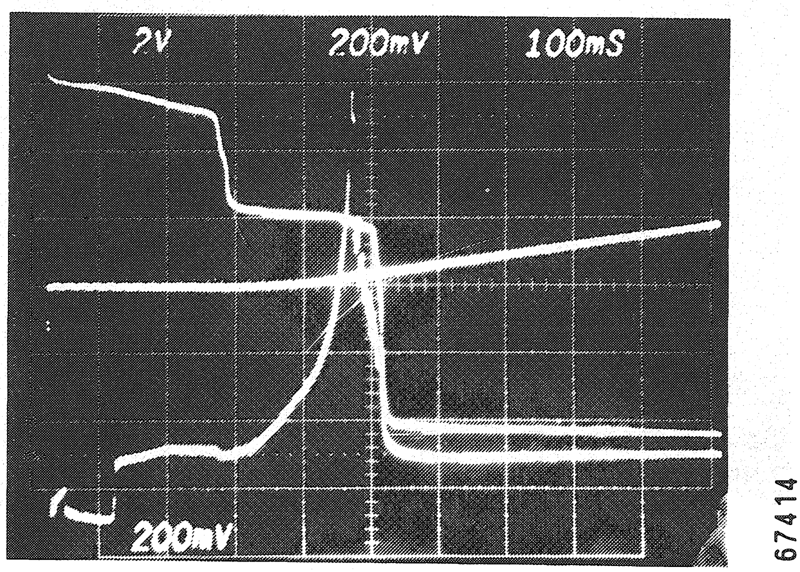


Fig. 1 Traces are BCT, MBA reference and peak wide band detected signals on a pulse exhibiting pronounced loss just after transition (intensity $\approx 10^{13}$ ppp)

The reason for the loss is not understood but we noted that at the loss point the LSF sextupole current regulation momentarily oscillates, the Q spread is large and there is coupling between the two transverse planes. Attempts to move Q by small increments at the loss point demonstrated that the Q spread completely fills the space between resonances.

On the other hand the loss is sporadic and suspiciously reminiscent of collective effects.

The horizontal IBS showed large emittance blow up at the end of the 200 GeV flat top. At the moment with its minimum resolution limited to ± 7 mm and without IBS's in other locations one cannot be sure in which phase plane the blow up occurs (Fig. 2).

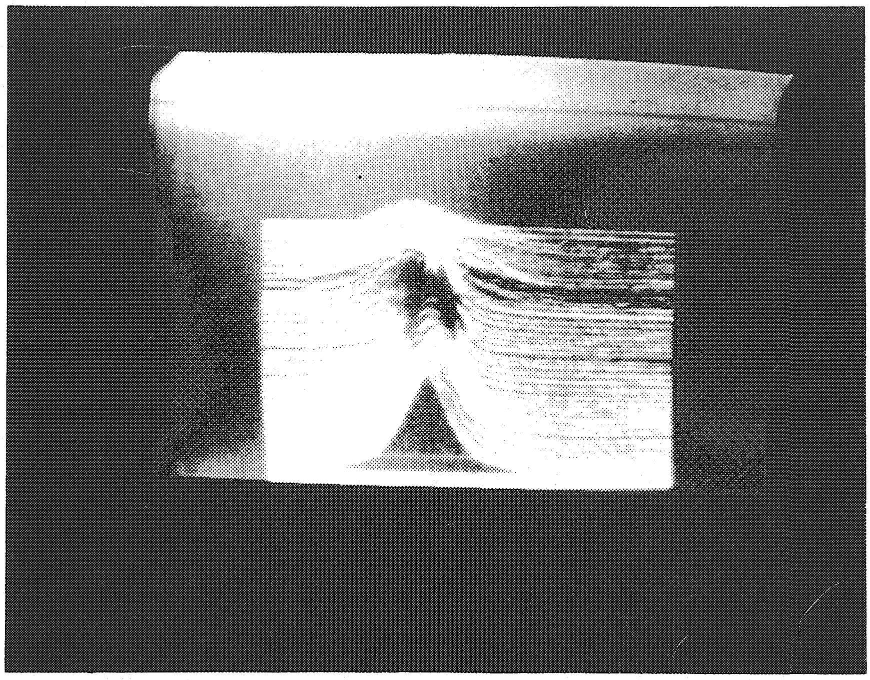
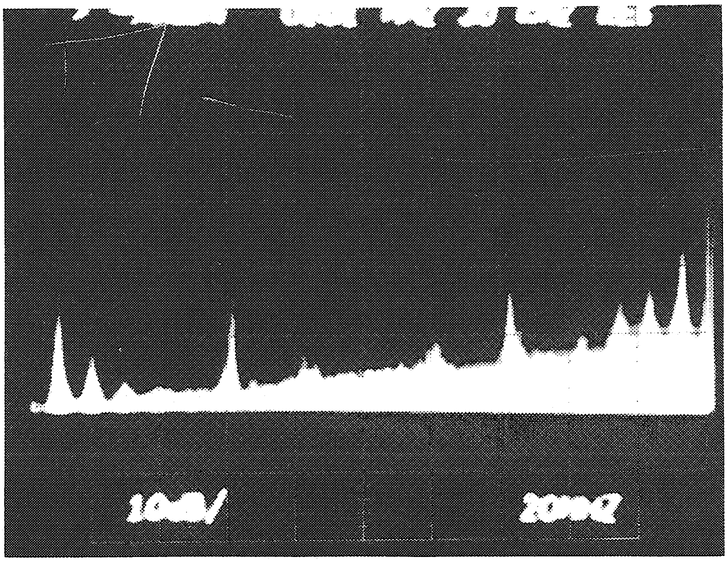


Fig. 2 IBS profile scanning from top to bottom throughout a complete acceleration cycle

For the first time the fast transverse beam pick up was fed into a spectrum analyser and, at the instant of blow up, sidebands at ± 60 MHz about each r.f. harmonic were seen (Fig. 3).



67415

Fig. 3 Wide band transverse pick up spectrum from 0 to 200 MHz shows peaks at 60 and 140 MHz

This leads us to speculate that transverse emittance blow up at high energy may not after all be due to single bunch head tail effect but to some resonant object. This observation has since been followed up in detail by the r.f. group (see later Commissioning Reports). It is a measurement which we had attempted on previous high intensity runs but had been defeated by drift or lack of stability in the beam.

Conclusions

Although the losses inherent in the double pulse injection of more than 1.5×10^{13} protons have not been cured they have been pinned down in a particular effect immediately following transition.

The fact that the design intensity was accelerated to 400 GeV and extracted at 200 GeV on a pulse with an intermediate flat top suggests that it would not be unreasonable to endeavour to make the double pulse injection mode operational in the near future. One is encouraged by the fact that setting up following a simple check list seems to result in high intensity and that thereafter the SPS remained stable.

The first pictures of discrete frequencies in the transverse pick up signals spectrum at a time which suggests they are symptoms of emittance blow up may herald a much better understanding of this phenomenon and its possible cure.

Reported by : E.J.N. Wilson