Fermilab

Transverse Instability Studies

Mike Halling, P.J. Chou, Pat Colestock
8/4/95

PURPOSE:

During collider operations last year a transverse instability was observed during PBAR transfers. The observation of an instability at such low intensities, and the fact that the motion appeared to be bounded instead of growing without limit, was intriguing, so we spent a few hours during last week's study period investigating the instability with some new diagnostic instrumentation.

These vertical instabilities occur usually with the damper systems off, and with the vertical chromaticity set near zero.

RESULTS:

The data that we took are still being analyzed, but a few preliminary results are described below. When viewed by the stripline detector readout by the RTD720 the phenomena appears to be a combination of a head-tail instability and a coupled bunch oscillation. This phenomena has been studied in detail by P.J. Chou and Gerry Jackson ("Experimental Studies of Transverse Beam Instabilities at Injection in the Fermilab Main Ring", Proceedings of PAC95, Dallas), although never at the extremely low intensities that we used (1 Booster turn 20 bunches). We captured a few samples of this behavior with the RTD720, but the long readout time of the device (~20 minutes through ACNET) limited our ability to make many measurements.

The instability was clearly visible on the TBT BPM display, which is sensitive to this type of beam motion through second order effects. The BPM's, though not useful for giving a detailed picture of the particle motion, are very useful at identifying the characteristic frequencies of the motion. Many frequencies are present in the motion, most of which we have not yet identified. One intriguing frequency that we did identify was the difference of the vertical tune from the half integer. There is near 100% modulation of the motion visible by the BPMs at this frequency.

We also captured some examples of the motion with the newly commissioned horizontal ion profile monitor (IPM). This device also shows many of the frequency components visible on the BPMs.

Another set of experiments were performed to explore the sensitivity of the instability to initial transverse betatron motion. We injected beam with the dampers on, then turned the dampers off and pinged the beam. We then measured the average time it took before beam loss. It was clear from this study that initial betatron oscillations decrease the amount of time it takes for the instability to grow. This confirms the behavior observed during the PBAR transfers when A1, which is not closed as well as the others, suffered the worse losses. In another test we measured the growth time to be of order 1000 turns. Furthermore, it was apparent that the super damper could not always damp the motion of the beam.

CONCLUSION:

Although the vertical instability in the main ring has been well studied in the past it surprises most of us that it now occurs at such a low intensity. We are starting an assessment of the instrumentation and other devices that have been added to the main ring in the last few years to search for devices that could have significantly increased the transverse impedance. It is discouraging that the existing super damper cannot always damp this type of motion, and that the only defense is non-zero chromaticity. This is further evidence of the need for an improved transverse bunch by bunch damper.