Head-Tail Instability in the Tevatron

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Coherent Instability = Weak Head-Tail

- Tevatron performance suffers from a transverse coherent instability (CI). After detailed experimental studies, this instability was identified as a single-bunch weak head-tail (WHT).
- In the most detailed recent measurements (P. Ivanov, V. Scarpine), all the features of WHT were observed:

1. The CI onset does not depend on the number of bunches;
2. When CI is developed, the transverse amplitudes and phases have proper modulation along the bunch;
3. The growth rates are always small compared with the synchrotron angle frequency.
4. To suppress CI, high chromaticities are required, which deteriorates the life time.

Simulations

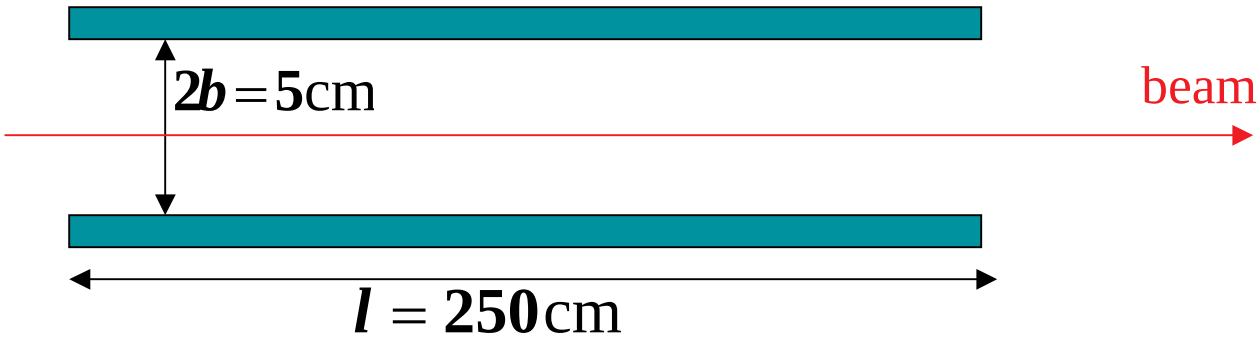
- To find out what impedance is responsible for the CI, I wrote a Monte-Carlo C++ code, which allows to put any given wake function(s), longitudinal distribution, initial conditions, and see the transverse beam dynamics in time domain. The code was tested for the air-bag longitudinal distribution, where the analytical results are known, and the perfect agreement has been found.
- Applied to the Gaussian longitudinal distribution (close to real one), with the Run II impedance model, the code gave the growth rate ~ 2 times smaller than measured one.

Where Is the Lost Impedance?

- Where it is not – Lambertson's contribution is ~10 times overestimated. After their removal, the disagreement goes to a factor of 3.

- We found that the underestimated guys are the 27 electrostatic separators.

Separators



The image currents 100% reflection from the free downstream end of the separators leads to a step-like transverse wake:

$$W(s) = \frac{2}{b^2}\left(\theta(s) - \theta(s - 2l)\right) \cdot \begin{cases} 0.82, & \textit{vertical} \\ 0.41, & \textit{horizontal} \end{cases}$$

Agreement

- After this separators wake was introduced into the code, the CI growth rate was calculated exactly as it has been measured (110 1/s versus 120±15 1/s) !

- The Conclusion:

  Now, we are sure that we really do know the Tevatron impedance.

How Could It Help?

- To be able to keep the beam at low chromaticities, several medicines can be tried:

1. Termination downstream ends of the separators by RC, with R=50 Ohms and C ~ 200 pF should suppress their wake by a factor 4-6. Test benchmark measurements are already in short-term plans of V. Shiltsev.
2. Landau cavity: simulations will be shortly.
3. Octupoles: measurements and simulations.

Best composition of these ingredients is to be found.