**Transverse instabilities in the Fermilab Booster**

**Abstract:**

Using the Synergia simulation package with a realistic lattice model and realistic wake functions we investigate the coherent tune shift and the instabilities at the injection energy in the Fermilab Booster.  
The simulated beam dynamics, the instabilities and the tune shift behavior are in good agreement with experiment.

**Summary:**

Experimental measurements show the presence of large wake fields[1] and horizontal beam instability[2] in the Fermilab Booster. We calculate the wakes in the laminated magnets[3] and find them to be four order of magnitude larger than in the metallic straight section. At short distance, within a bucket length, the vertical wake is about twice larger then the horizontal one. However, compared to the horizontal wake, the vertical one decreases faster with distance. At distances larger then one bucket length the horizontal wake is larger. Using Synergia we ran single- and multi-bunch simulations with realistic lattice model, space charge and wake fields. We find a large decrease of the vertical tune shift and a small increase of the horizontal tune shift with intensity, in good agreement with experiment. Our analysis shows that the instability is caused by short range (order of a a few bucket lengths) bunch-bunch interactions via dipole horizontal wake. The reason for instability to be in the horizontal plane is twofold. One cause is the large lattice beta functions at the location of the focusing magnets which couple with the horizontal wake. The second cause is that at the relevant distance the horizontal wake is larger than the vertical one.

[1] D. McCarron,PhD Thesis, FERMILAB-THESIS-2010-50, (2010).  
  
[2] Y. Alexahin et al., FERMILAB-CONF-12-219-AD-APC, IPAC-2012-WEPPR085.  
  
[3] A. Macridin et al., Phys. Rev. ST Accel. Beams 14, 061003 (2011), Phys. Rev. ST Accel. Beams 16, 121001 (2013).