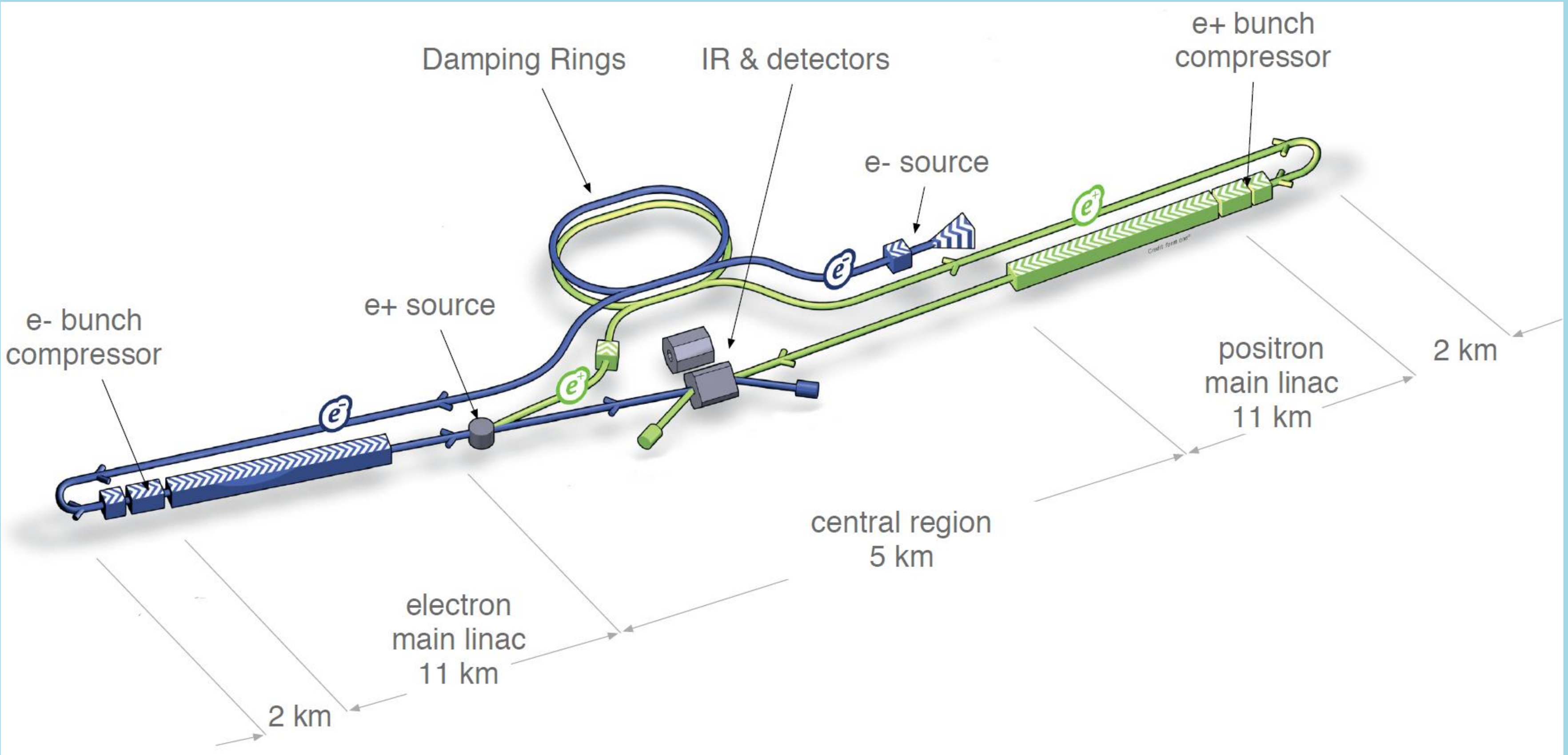
IP Feedback Ground Motion Simulation Studies for the ILC

R.M. Bodenstein, N. Blaskovic Kraljevic, T. Bromwich, P. N. Burrows, G. B. Christian, C. Perry, R. Ramjiawan
John Adams Institute, University of Oxford, Oxford, UK
J. Pfingstner – CERN, Geneva, Switzerland

Abstract

The International Linear Collider (ILC), as described in its Technical Design Report (TDR), must maintain strict control of its electron and positron beams in order to achieve the desired luminosity at each of its proposed center-of-mass energies. Controlling the beam parameters requires a dynamic system, capable of adjusting to a myriad of perturbations and errors. One of the components used to control the beam is the Interaction Point (IP) feedback system, which is used to dynamically steer the beams back into collision within nanoseconds. This work will show the simulation of the IP feedback system's compensation for ground motion model K at the ILC.



Introduction

- Linear colliders require exceptionally strict control over beam parameters to achieve an acceptable luminosity.
- Proposed ILC site in northern Japan, which has high levels of ground motion.
- Ground motion model K measured at KEK in Tsukuba.
- FONT's IP Feedback system is capable of recovering luminosity lost to ground motion and maintain a stable luminosity throughout bunch train.

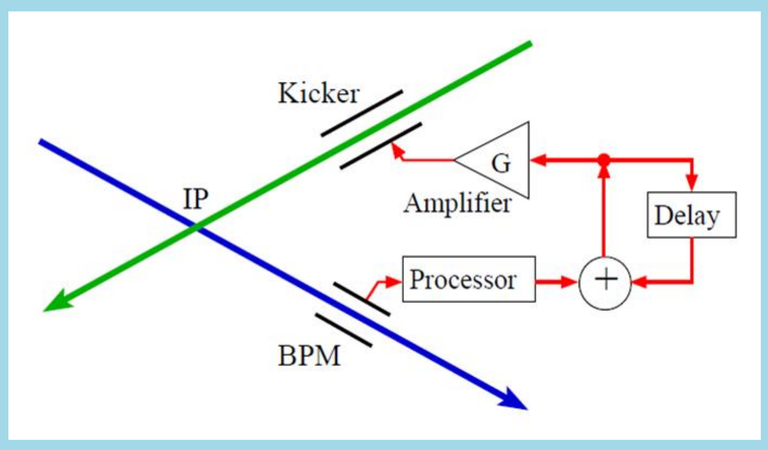
The Simulations

- After scanning through a series of gain settings for the IP FB dipole kicker, the gain which corresponds to the highest luminosity recovery is selected.
- Luminosities are measured for each bunch.
- The ratio of $\mathcal{L}$ to $\mathcal{L}_{FBoff}$ is plotted against bunch number to show the luminosity recovery relative to the uncorrected first bunch.
- The plots also show that the recovered luminosity is maintained through the entire bunch train.
- In the plots, the shaded region represents the standard error.

FONT IP Feedback Overview

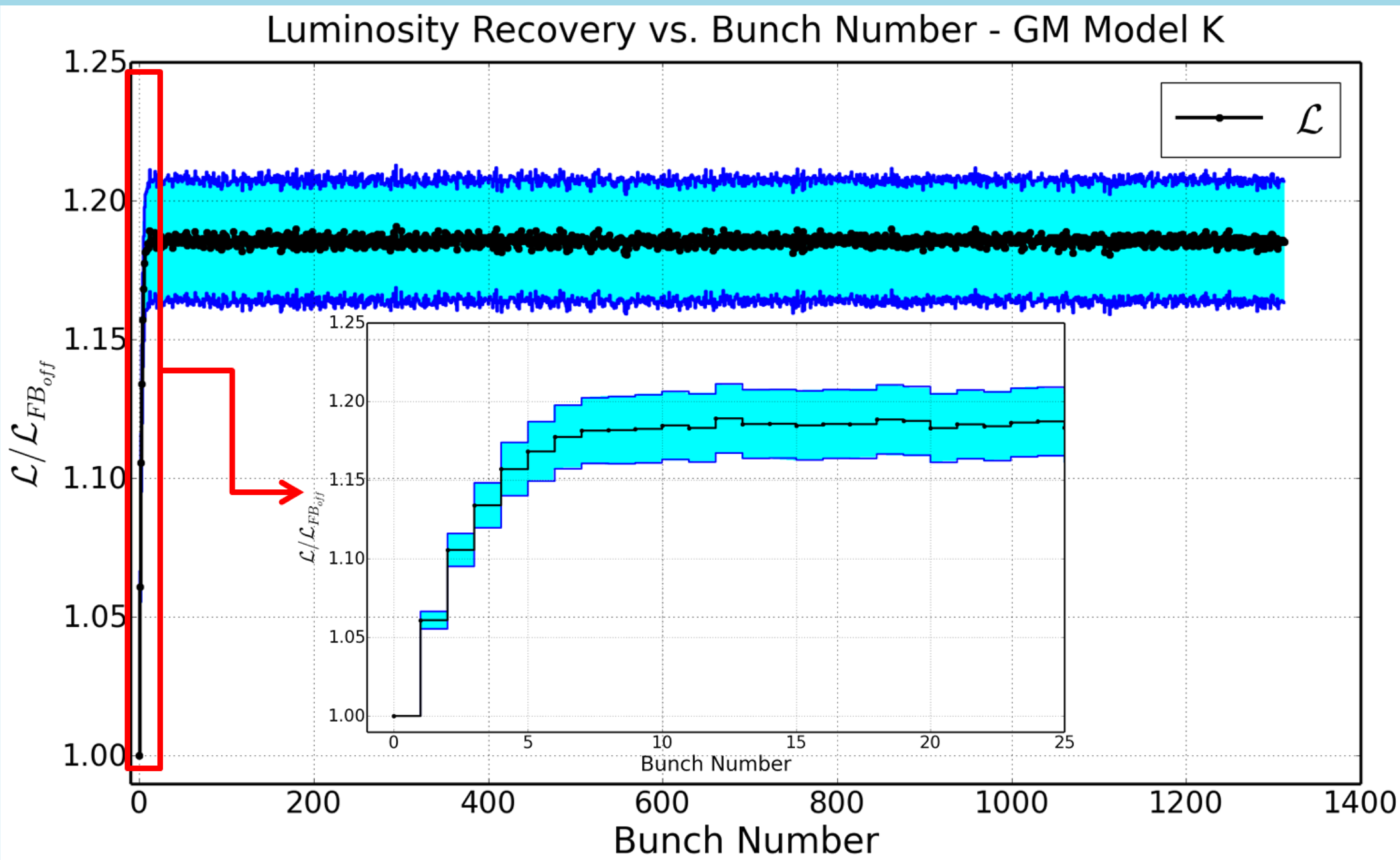
- Beam position monitor measures the deflection angle of the beam after it interacts with its counterpart.
- FONT system uses this information to calculate the offset of the incoming beam centroid.
- Signal is sent to upstream dipole kicker, which steers the beam centroid back toward the nominal trajectory.
- Entire process occurs in nanoseconds, allowing for rapid feedback and luminosity recovery.

Parameter	Value	Units
Collision Rate	5	Hz
Number of bunches	1312	
Bunch Population	2	10^{10}
Bunch separation	554	ns
Luminosity	1.8	10^{34} cm^{-2}s^{-1}
IP Horizontal Beam Size	474	nm (RMS)
IP Vertical Beam Size	5.9	nm (RMS)



The Background

- Focusing on the 500 GeV center-of-mass collision energy ILC, as described in the TDR.
- Focus on ground motion model K, as it has the most site-specific relevance.
- Simulations use the LinSim framework for the simulation programs PLACET and GUINEA-PIG.
- Simulations currently performed in vertical plane, as it has significantly stricter control requirements due to the smaller beam size.
- 100 random seeds of vertical ground motion are applied to the beam delivery system, misaligning the elements and decreasing the luminosity.
- All other feedback systems and tuning is turned off, and the FONT intra-train IP feedback system is used to steer the beam centroid back to its nominal trajectory.
- The FONT FB system can only recover the luminosity lost due to the linear aberrations, as it uses a dipole kick. Higher-order aberrations must be addressed with other systems.



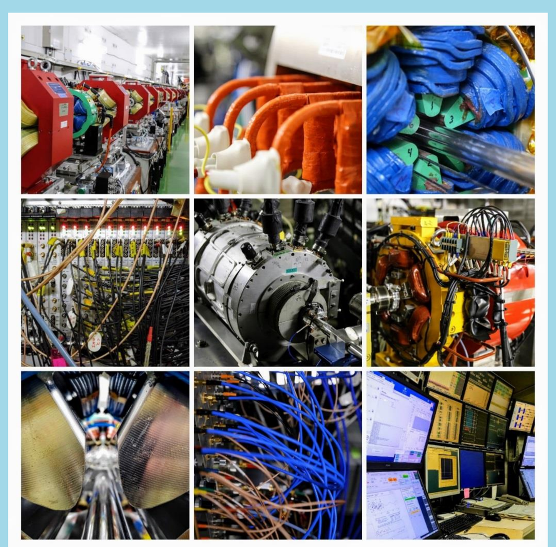
Where does this lead?

- More factors must be added to make the simulations more realistic.
- Other feedback and tuning systems must be turned on.
- Both planes should be investigated.
- The beam distribution itself must be studied, as it may give clues as to the nature of the higher-order aberrations which contribute to the luminosity loss.
- Other models of ground motion must be studied in detail.
- Perhaps combination of multiple models.

Conclusions

- Ground motion model K provides too large a disturbance to the BDS to be corrected by the IP feedback system alone.
- FONT's intra-train IP feedback system is capable of recovering luminosity lost due to the increased beam offsets caused by the ground motion.
- Once recovered, the FB system can maintain a stable luminosity for the entirety of the bunch train, which is on order 725,000 ns.
- Further work is required to fully understand how to best compensate for model K.

Please see proceedings for references.



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