Some studies on luminosity performance applying different jitter sources and IP-FB correction for Linear Colliders

Javier Resta Lopez
JAI, Oxford University

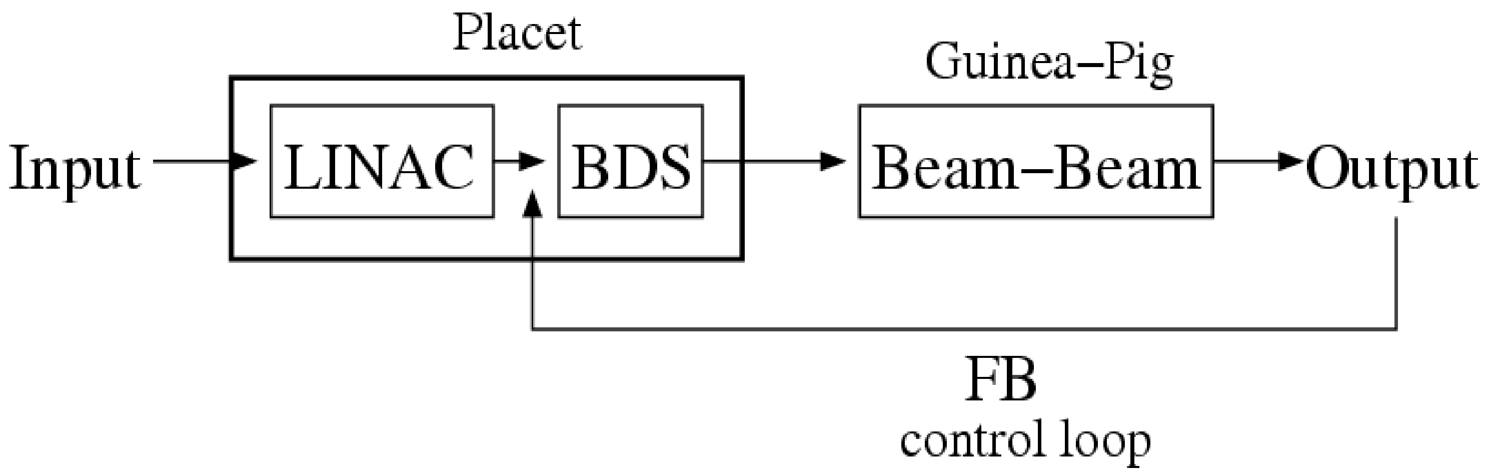
In collaboration with P. N. Burrows, A. Latina and D. Schulte

Introduction

Train structure

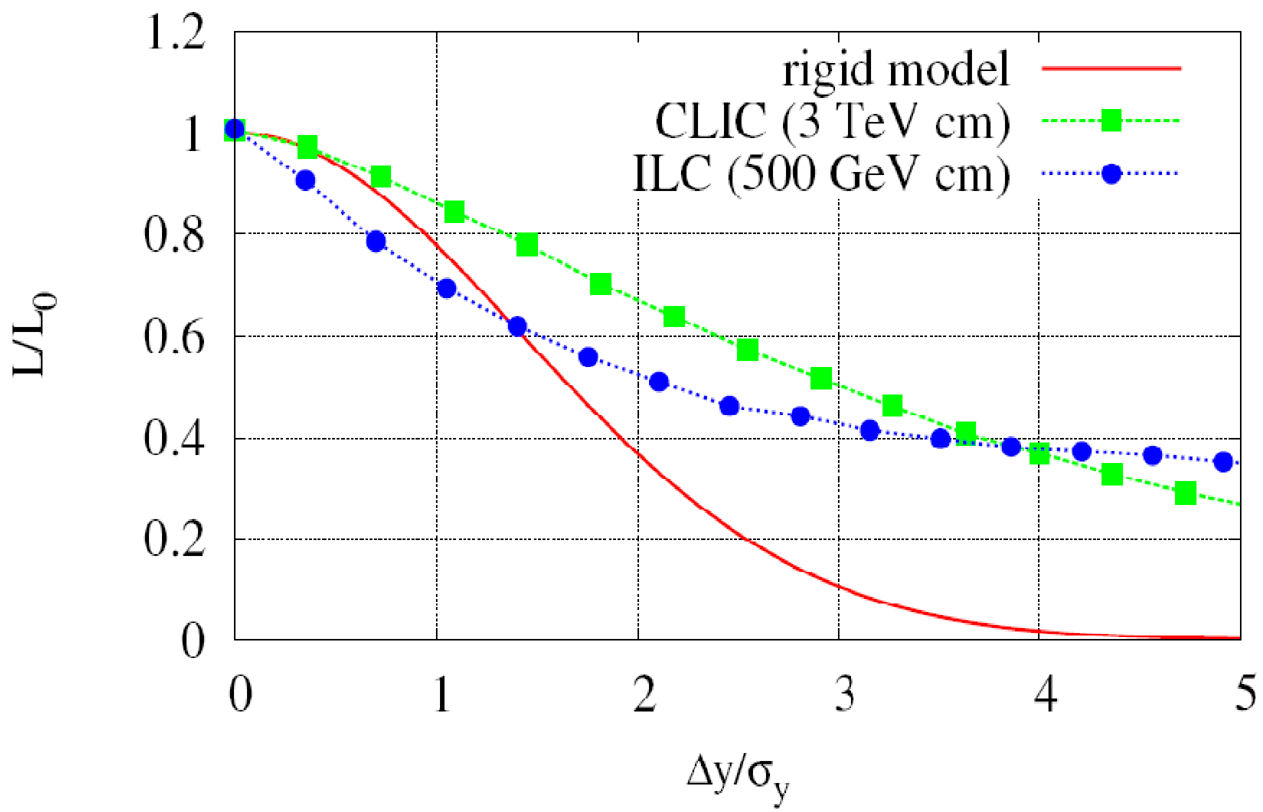
Property	ILC 500 GeV	CLIC 3 TeV	units
Electrons/bunch	2.0	0.37	10^{10}
Bunches/train	2820	312	
Train Repetition Rate	5	50	Hz
Bunch Separation	308	0.5	ns
Train Length	867.7	0.156	μs
Horizontal IP Beam Size (σ_x)	655	45	nm
Vertical IP Beam Size (σ_y)	5.7	0.9	nm
Longitudinal IP Beam Size	300	45	μm
Luminosity	2.03	6.0	$10^{34}\mathrm{cm}^{-2}\mathrm{s}^{-1}$

Simulation procedure



Example of luminosity loss

versus the relative offset of the colliding beams



For instance, in order to maintain the luminosity 10% of nominal the relative beam-beam position needs to be stabilised to within 🕔$0.5\sigma_y$ for ILC and 🕔$1\sigma_y$ for CLIC

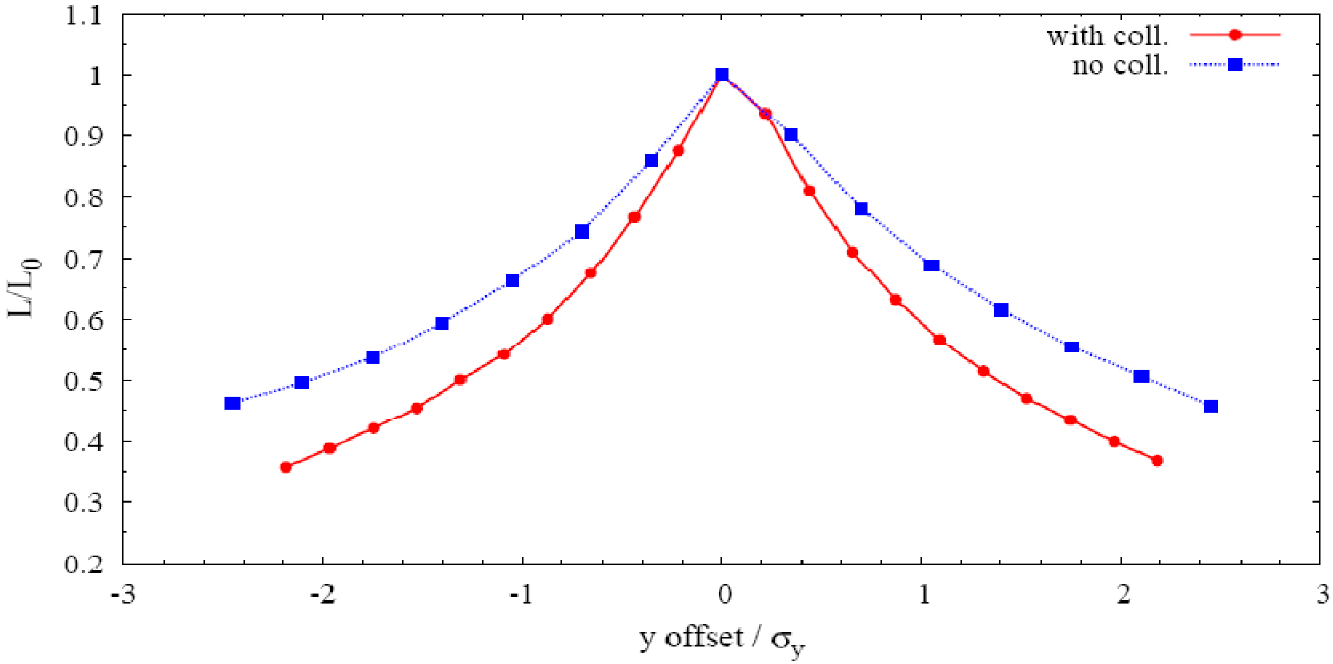
ILC

- Collimator wakefield effects
- IP intra-train beam-based FB system
- Luminosity results
  - different scenarios of GM
  - Applying additional beam jitter at the entrance of the BDS

Collimator wakefield effects

ILC luminosity

- Luminosity loss versus initial vertical position jitter at the entrance of the BDS
- The join effect of all the BDS collimators is considered



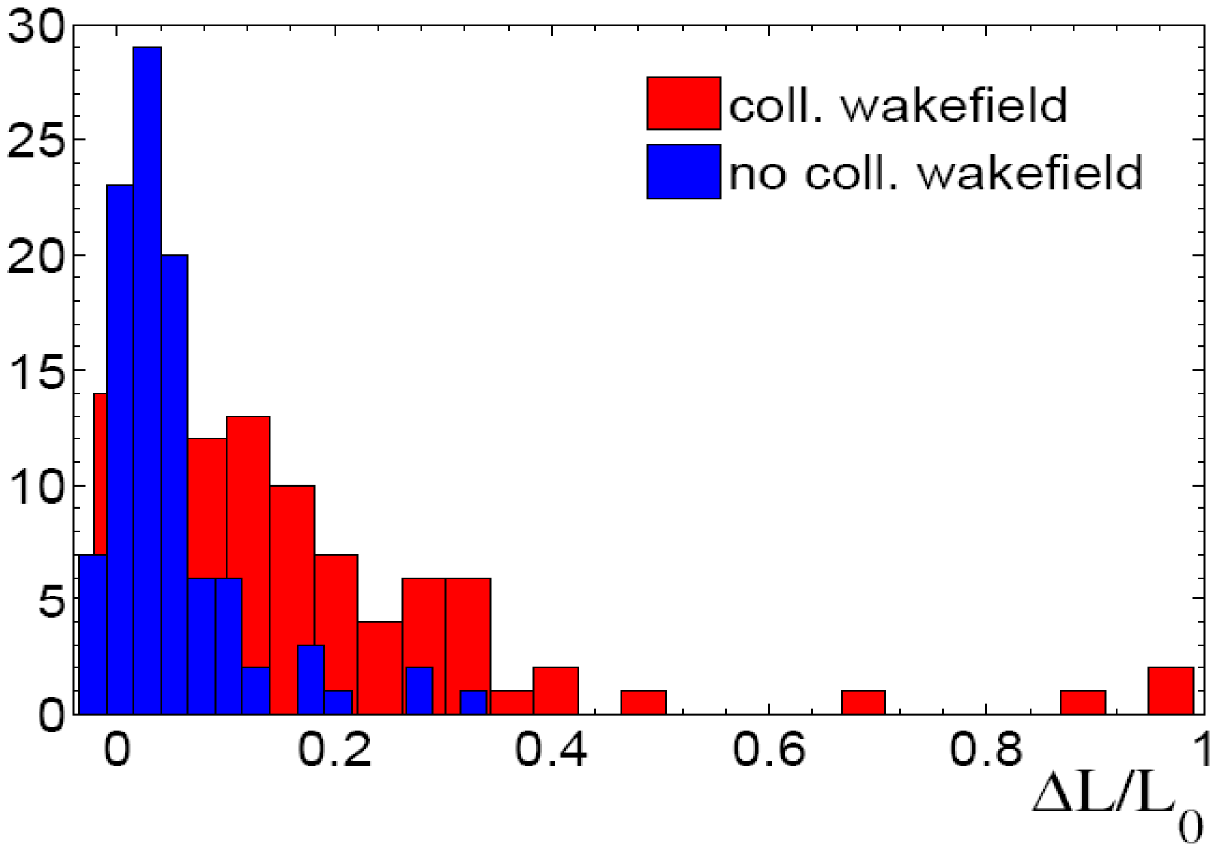
Jitter tolerance ⌚ $0.2\ \sigma_y = 0.4\ \mu m$ (~ 10% luminosity loss)

The jitter position of the incoming beam at the entrance of the BDS should be corrected at the submicrom level, for example by mean of precise orbit steering feedback systems using cavity BPMs and stripline kickers

Collimator wakefield effects

CLIC luminosity

Simulation of 100 machines, assuming $0.2\sigma_y$ jitter at the BDS entrance (using a normal offset distribution)



IP intra-train beam-based FB for ILC

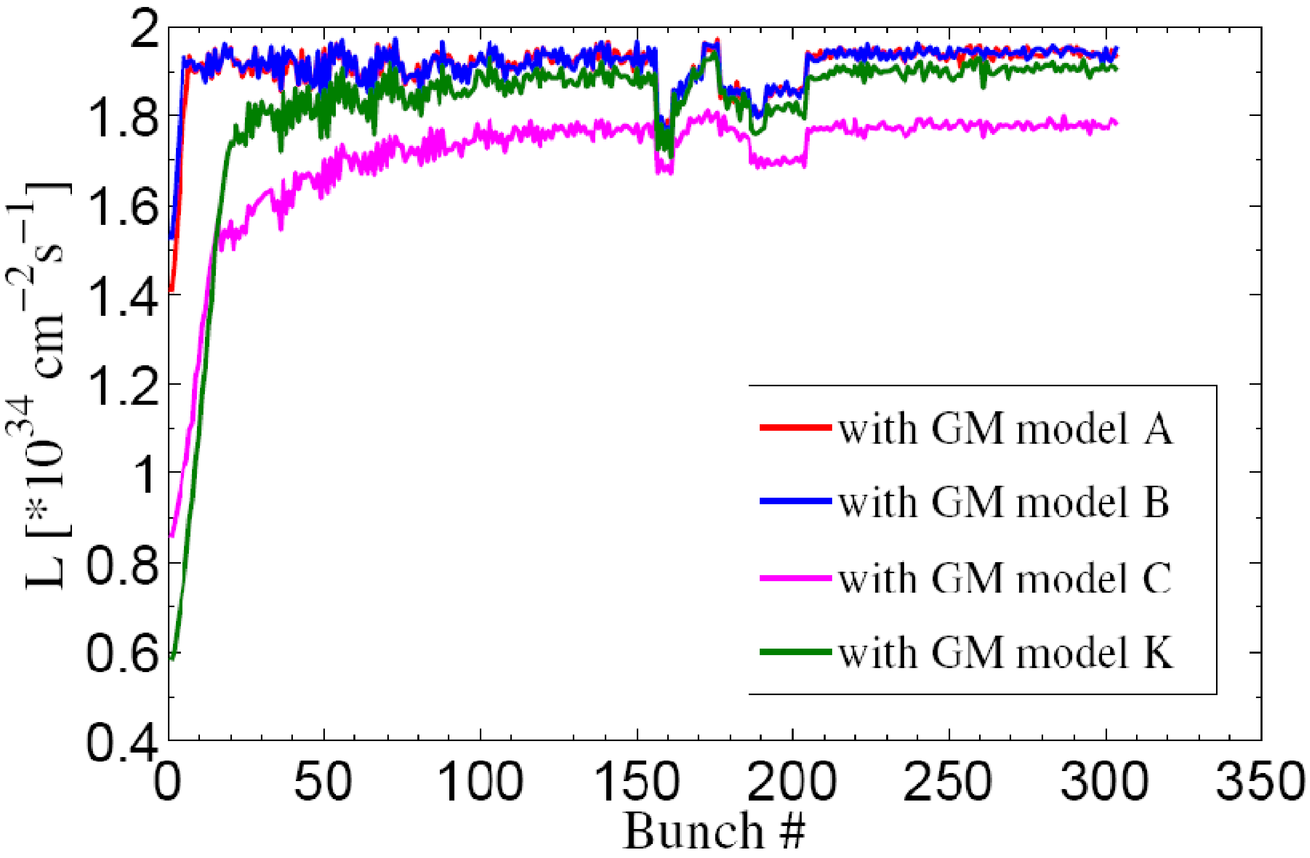
- The ILC train timescale structure allow the bunch-to-bunch feedback system using digital FB processors (demonstrated by FONT4 at ATF)

- For beam-beam relative position correction at the IP:
  - Stripline kicker near the IP in the incoming beamline between the sextupole SD0 and the final quadrupole QF1
  - BPM (1μm resolution) at $\pi/2$ phase advance downstream of the IP
- For angle correction a stripline kicker at the entrance of the FFS with a downstream BPM at $\pi/2$
- For the simulations we use a FB loop based in a proportional and integral (PI) control algorithm

ILC luminosity results

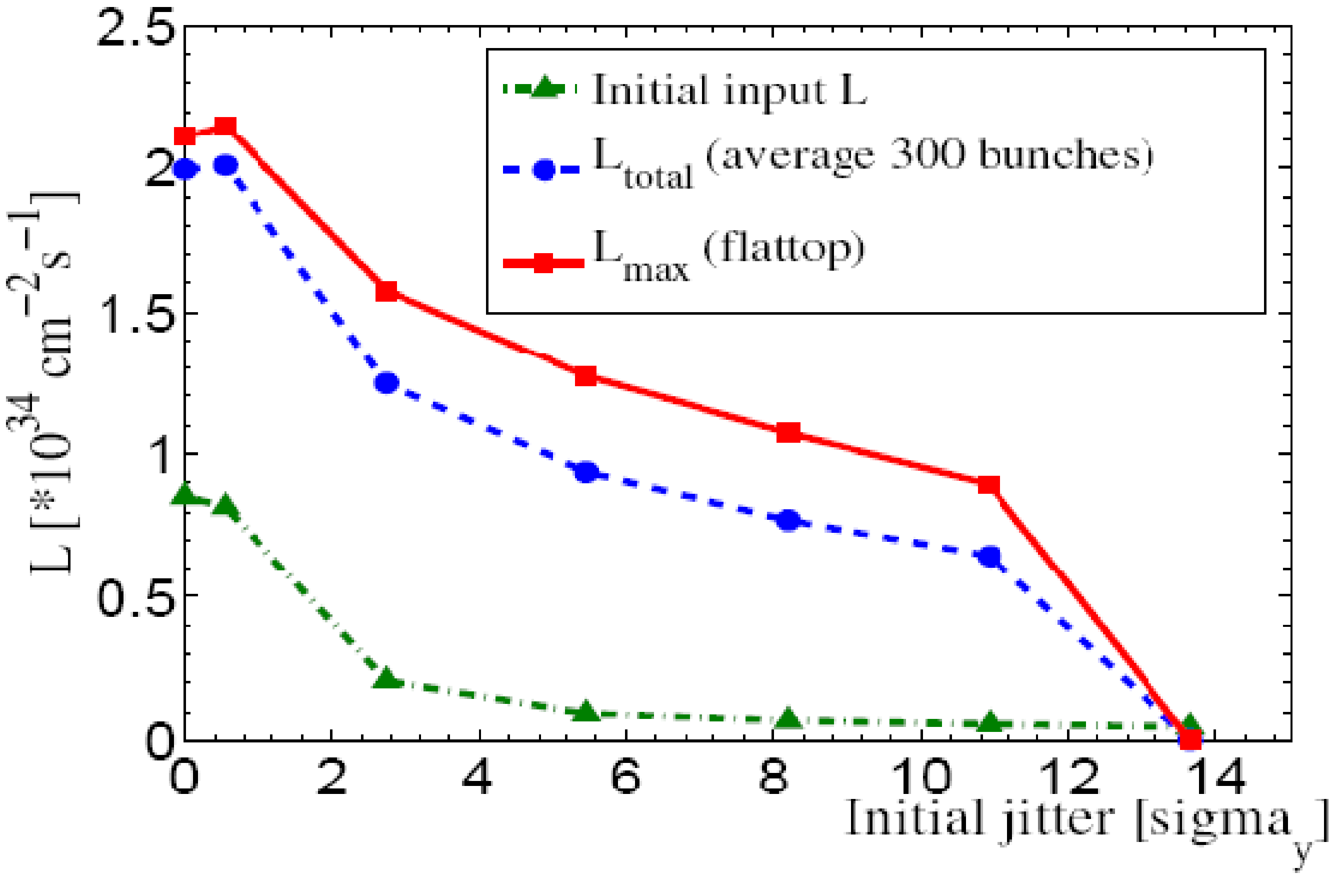
Different scenarios of ground motion

Example for 1 single random seed



ILC luminosity results

with additional beam jitter at the entrance of the BDS



ILC Luminosity results

cpu time

Remark:

- Start-to-end simulation (of the first 300 bunches) Linac+BDS+Beam-beam with IP- FB system for 1 single seed of GM: cput=02:04:18 in the Oxford Particle Physics Cluster with 2.0, 2.4 and 2.8 GHz Xeon processor running Linux

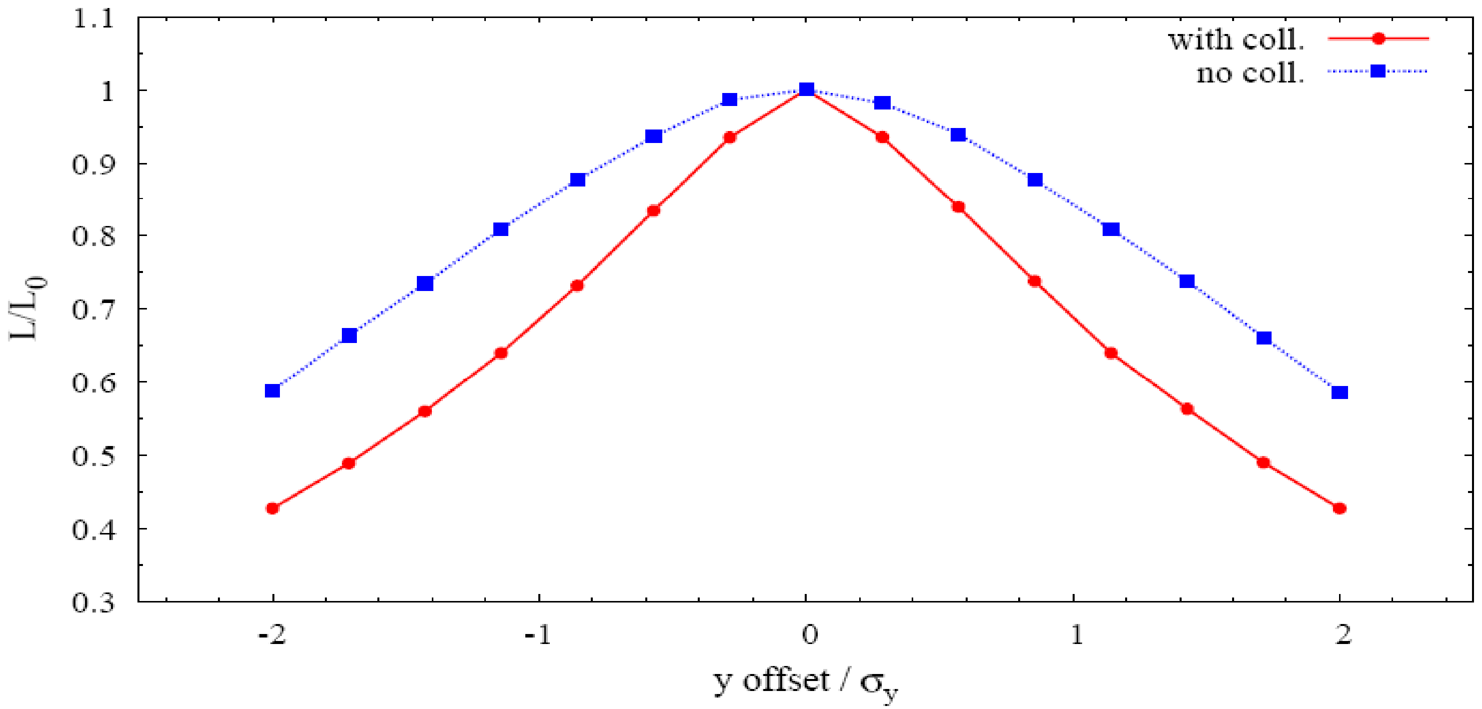
- If collimator wakefield calculation included (bipolar and quadrupolar modes implemented in Placet), the cput is much longer (addition of 10 minutes per bunch)

CLIC

- Collimator wakefield effects
- IP intra-train beam-based FB system
- Luminosity results
    - different scenarios of GM
    - Applying additional quadrupole position jitter

Collimator wakefield effects

CLIC luminosity



Position jitter tolerance $0.2\ \sigma_y \approx 0.1\ \mu m$ (~ 10% luminosity loss)

The jitter position of the incoming beam at the entrance of the BDS should be corrected at the submicrom level, for example by mean of precise orbit steering feedback systems using cavity BPMs and stripline kickers

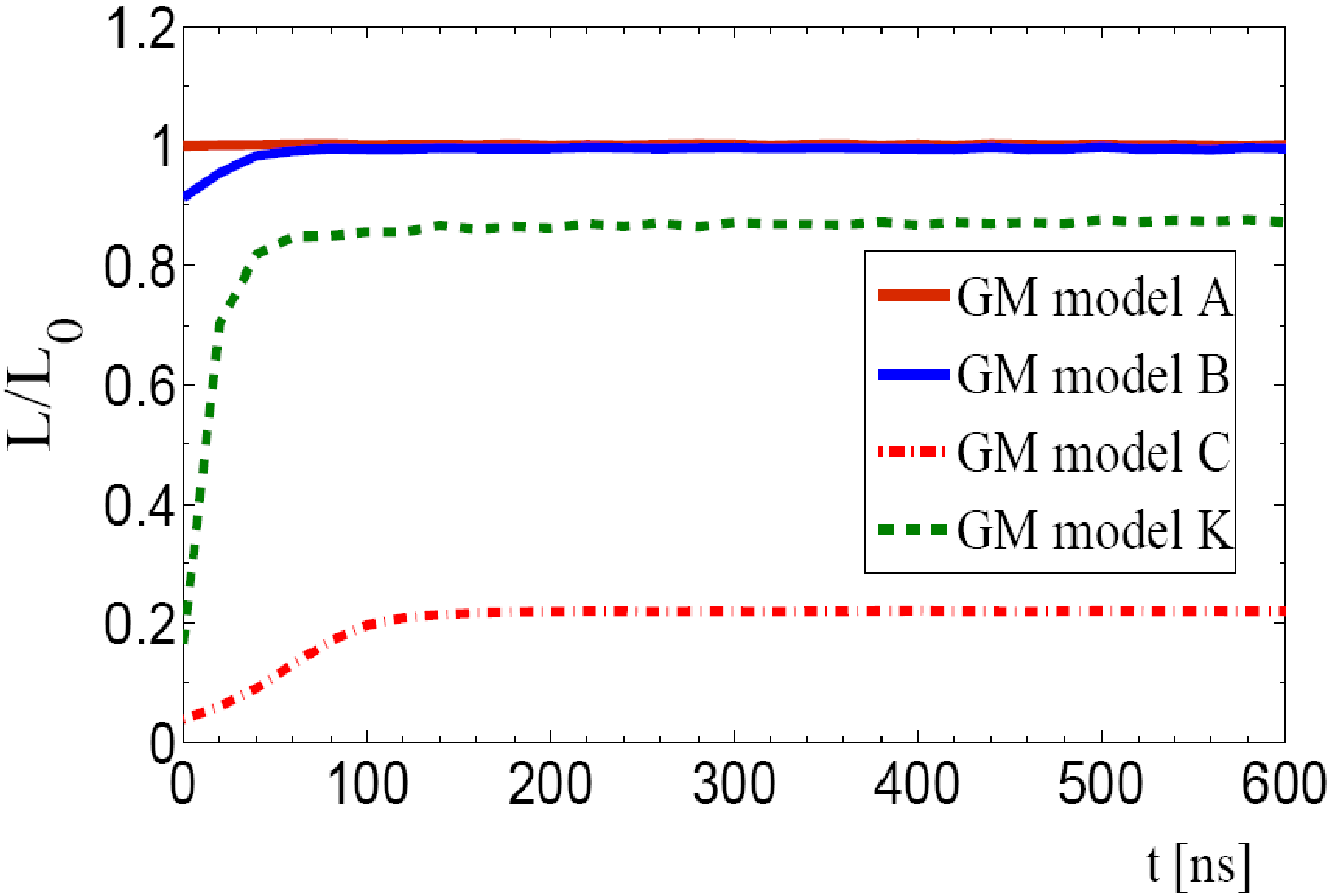
IP intra-train beam-based FB for CLIC

- For CLIC with nominal inter-bunch separation of 0.5 ns and a nominal train length of 156 ns the design of an IP intra-train FB is very challenging
- For beam-beam relative position correction at the IP:
  - Stripline kicker located the incoming beamline immediately downstream of the final quadrupole QD0
  - BPM (1μm resolution) at $\pi/2$ phase advance downstream of the IP
- Due to latency constraints no angle intra-train FB system designed for CLIC
- Latency times of about 20 ns have experimentally been demonstrated by the FONT3 system using a FB analogue processor.
- For the simulations we have considered a correction iteration every 20 ns. The systems performs approximately a correction every 40 bunches
- In this case we have employed a FB control loop based in a simple proportional control algorithm

CLIC luminosity results

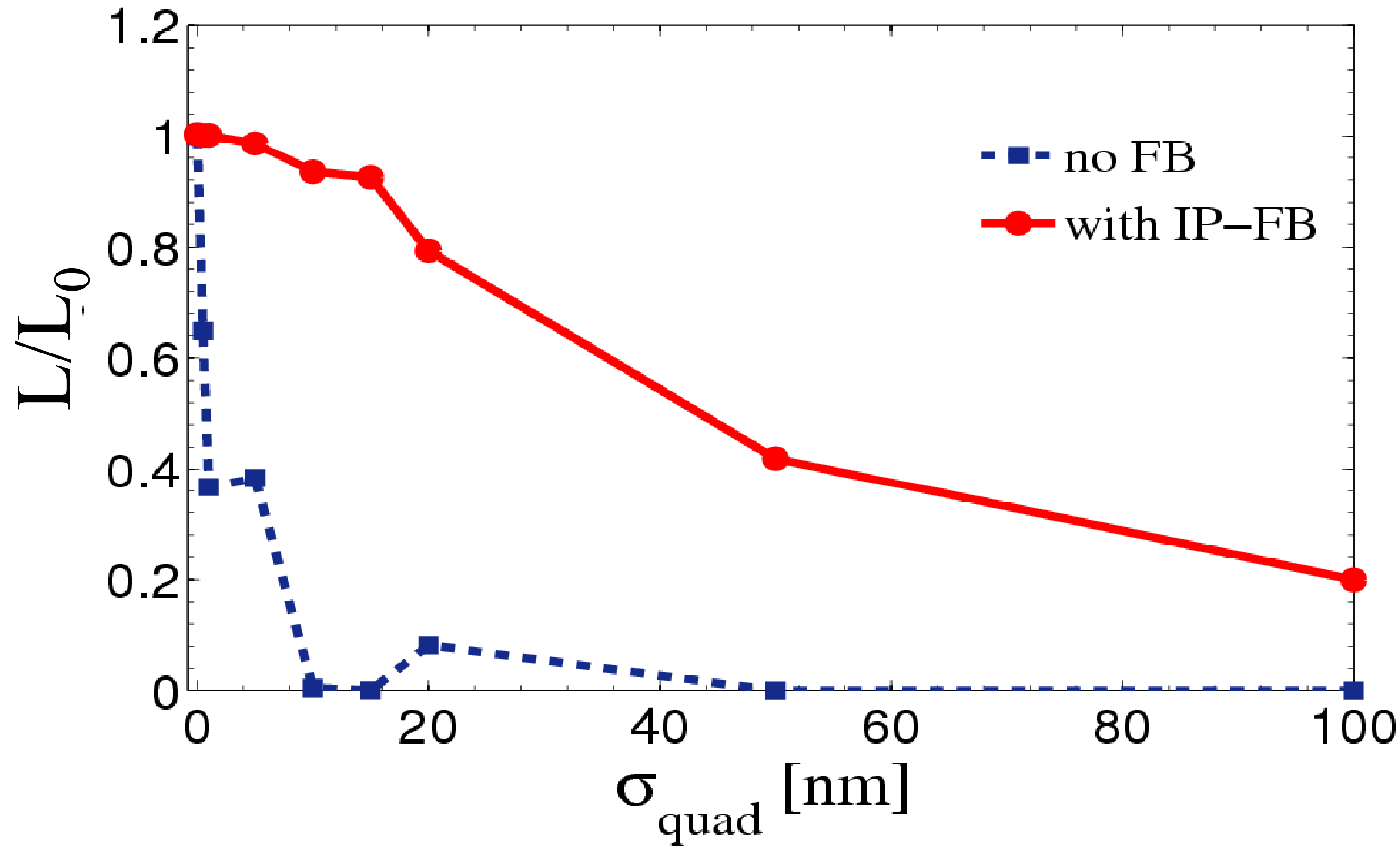
Different scenarios of ground motion

Example for 1 single random seed



CLIC luminosity results

Introducing additional quadrupole position jitter



Ongoing experimental tests of fast FB for LC

- In the context of the Feedback On Nano-second Timescales (FONT) project
- Fast intra-train FB located in the ATF2 EXT line
- May be results mid 2009
- Goal:

  Control of beam position down to 5 % of the rms vertical beam size at the IP, which will require a stability control better than 1μm at the ATF2 final focus entrance