Some studies on CLIC luminosity performance with intra-train FB system at the IP and (‘slow’) orbit correction in the BDS

Plan for integrated simulations

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Beam Control Stability Issues

IP jitter control:

- IP beam stability mainly provided from:
  - Selection of a site with sufficiently small ground motion
  - Pulse-to-pulse FB systems for orbit correction in linac and BDS
  - Active stabilisation of the FD quadrupoles
  - Interaction region stability (detector stability, etc.)

- A fast intra-train FB system is thought as an additional line of defence to recover at least ~ 80% of nominal luminosity in case of failure of the above stabilisation subsystems.

- A fast FB system can also help to relax the FD subnanometer position jitter tolerance, which in the case of CLIC ~ 0.1 nm for the vertical position

Here we show some example results of luminosity performance improvement using a beam-based intra-train FB systems in terms of correcting vertical IP jitter generated by ground motion

Beam tracking simulations

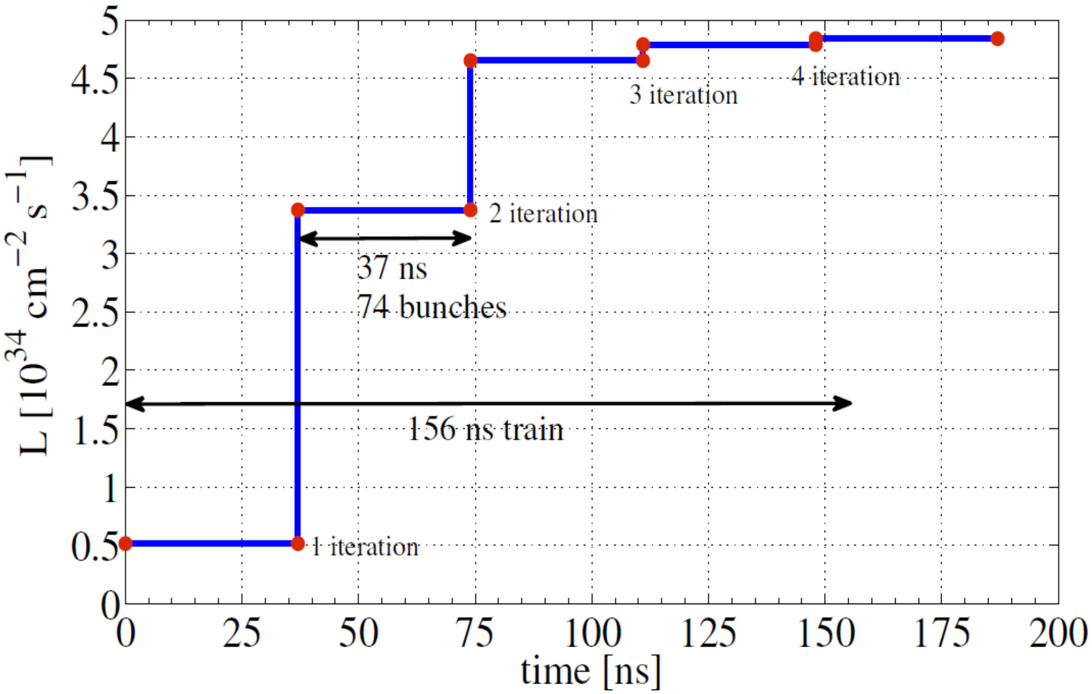
- Ground motion:
  - In the following simulations we apply 0.02 s (corresponding to f_{rep}=50 Hz) of GM (A. Seryi's models) to the CLIC BDS
  - What is the RMS vertical beam-beam offset at the IP we have to deal with?
    - Simulation of 100 random seeds:

GM model	rms Δy^* [nm] (in units of σ_y^*)
A (CERN)	0.035 (0.04)
B (SLAC and FNAL)	0.47 (0.52)
C (DESY)	8.9 (9.9)
K (KEK)	6.4 (7.1)

- Macroparticle tracking through the BDS using the code PLACET
- Luminosity calculation using the code Guinea-Pig
- In the simulations we take the average luminosity over a train

Luminosity performance with IP intra-train FB

Simulation time structure:
Example applying a single random seed of GM C



- For the simulations we have considered a total feedback latency of 37 ns. The systems performs approximately a correction every 74 bunches (4 iterations per train)

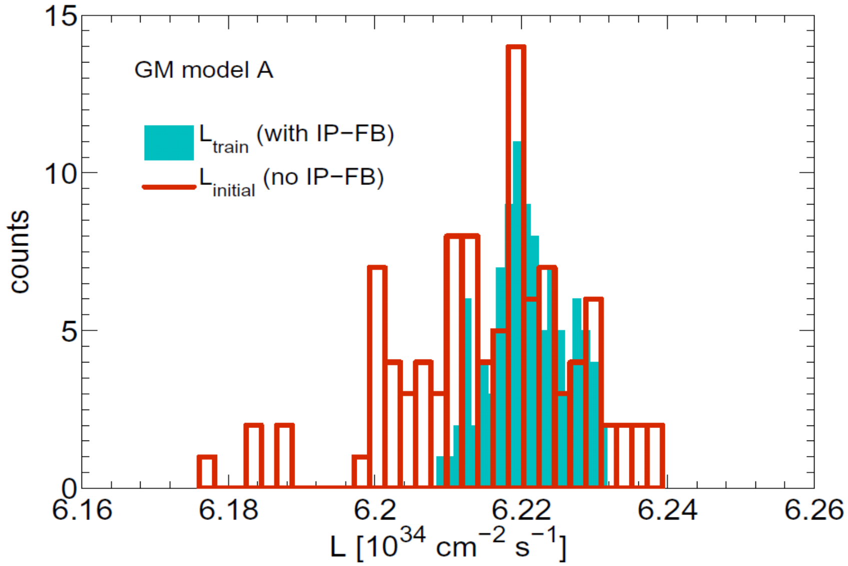
- For details on the IP-FB system of CLIC, see for example slides from the MDI CLIC meeting, 6 November 2009: http://indico.cern.ch/conferenceDisplay.py?confId=69100

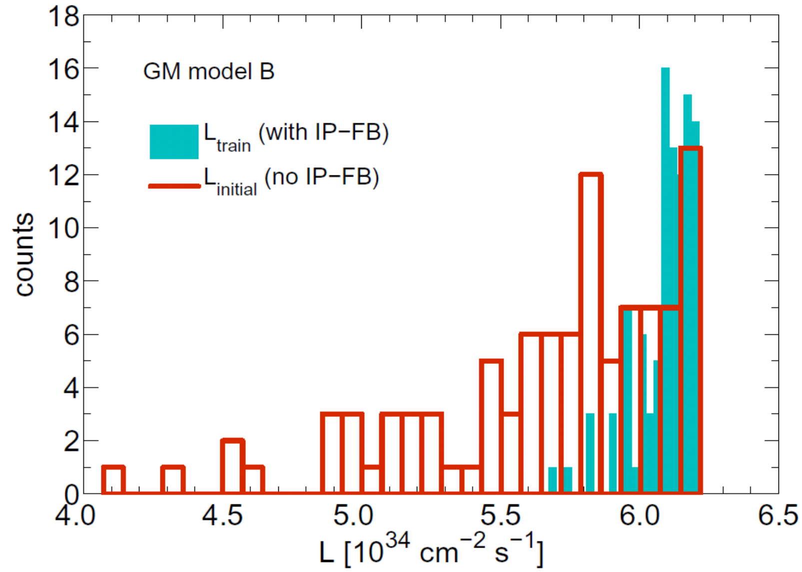
CLIC luminosity result with IP-FB

Different scenarios of ground motion

Luminosity distribution for simulation of 100 random seeds of the GM

For quiet sites:





The generated IP-jitter is relatively small after 0.02 s of GM

Model A:

- Without any correction: mean $\langle L/L_0 \rangle_{train}$=99.88%
- With IP-FB: mean $\langle L/L_0 \rangle_{train}$=99.97%
  std reduced by a factor 2

Model B:

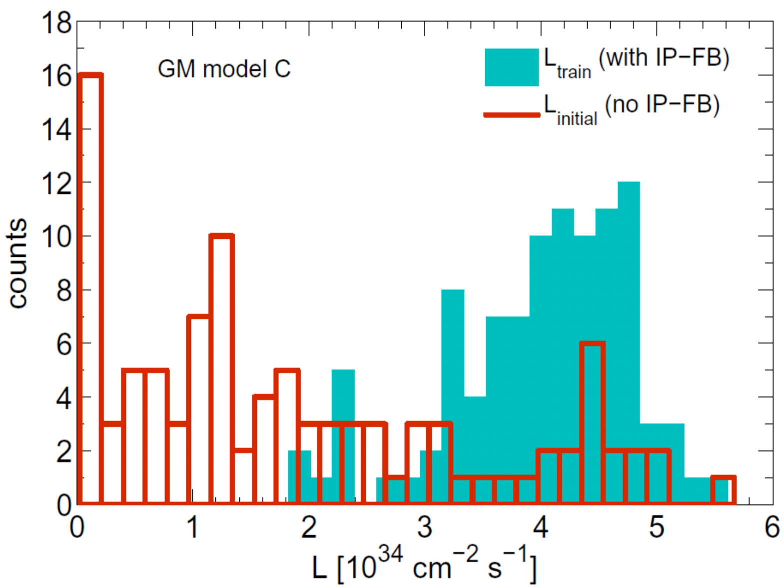
- Without any correction: mean $\langle L/L_0 \rangle_{train}$=91.1%
- With IP-FB: mean $\langle L/L_0 \rangle_{train}$=97.86%
  std reduced by a factor 4

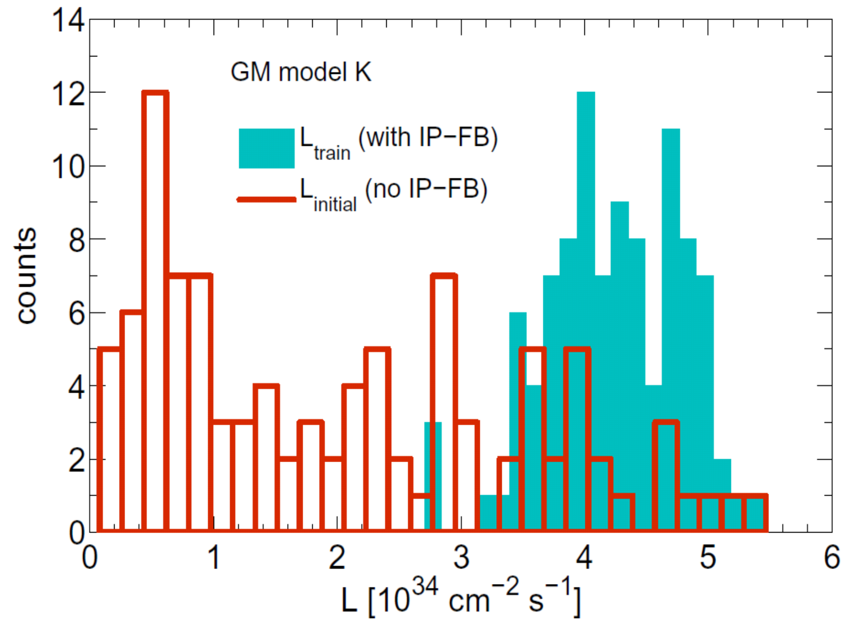
CLIC luminosity result with IP-FB

Different scenarios of ground motion

Luminosity distribution for simulation of 100 random seeds of the GM

For noisy sites:





In these cases significant luminosity degradation

Model C:

- Without any correction: mean $\langle L/L_0 \rangle_{train}$=30.52%
  & High standard deviation!
- With IP-FB: mean $\langle L/L_0 \rangle_{train}$=64.15%
  std reduced by a factor 2

Model K:

- Without any correction: mean $\langle L/L_0 \rangle_{train}$=32.53%
  & High standard deviation!
- With IP-FB: mean $\langle L/L_0 \rangle_{train}$=67.82%
  std reduced by a factor 3

Luminosity result with IP-FB

Different scenarios of ground motion

- Remarks:

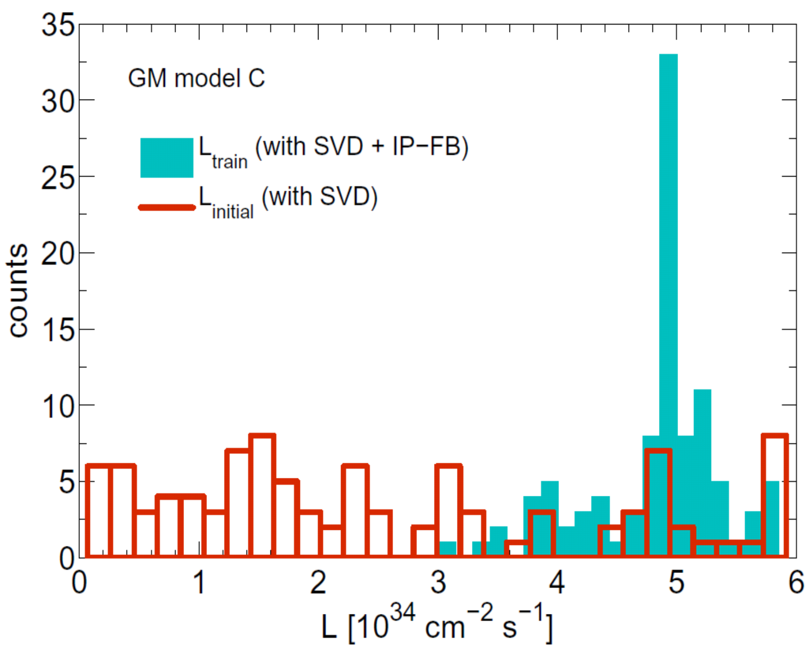
  Considering the most severe scenarios of GM (models C & K), intra-train FB systems at the IP are not enough to achieve the nominal luminosity. Obviously it is due to remaining uncorrected pulse-to-pulse jitter, which in principle can be corrected using a downstream inter-train FB systems.

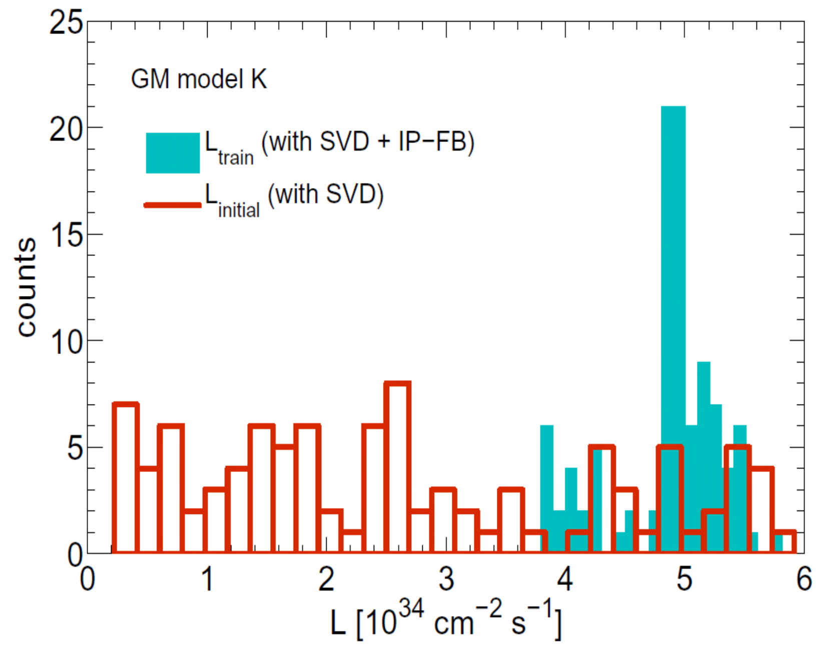
  For a more complete simulation we should consider the action of inter-train FB systems + intra-train FB systems + additional luminosity tuning.

Luminosity result with IP-FB

Different scenarios of ground motion

- If we consider:
  - GM (100 random seed simulation) +
  - orbit correction in the BDS (SVD) using the available BPMs (resolution 100 nm) and dipole correctors in the BDS +
  - IP-FB





Model C:

- SVD orbit correction: mean $\langle L/L_0\rangle_{train}$=41.1%
- SVD orbit + IP-FB: mean $\langle L/L_0\rangle_{train}$=77.51%

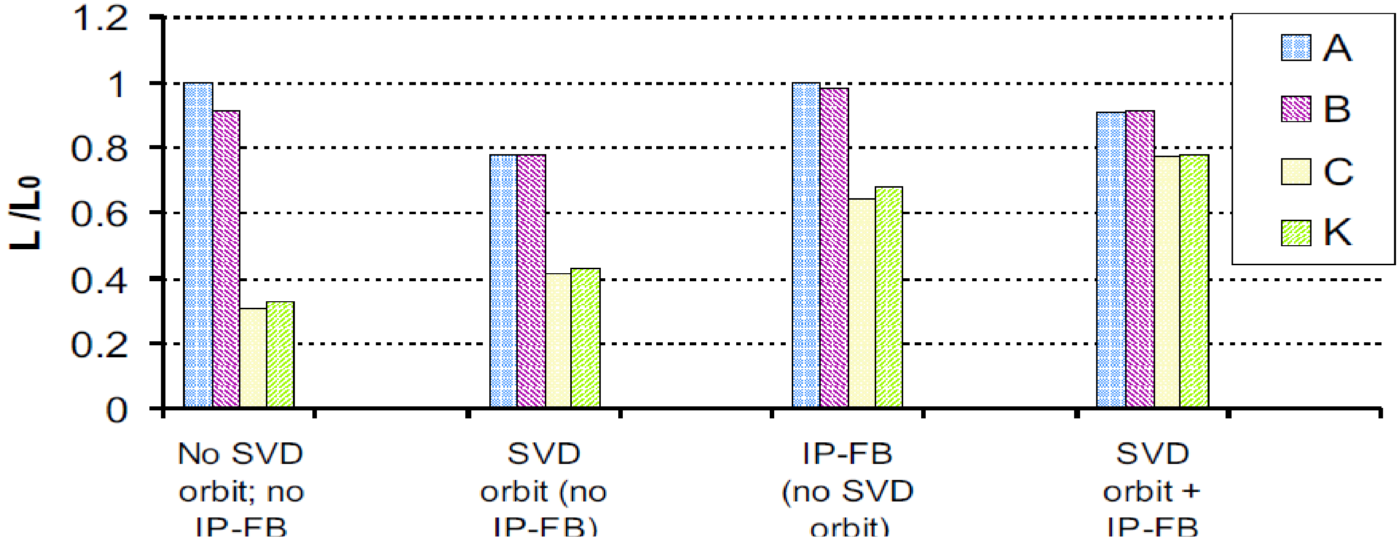
Model K:

- SVD orbit correction: mean $\langle L/L_0\rangle_{train}$=42.63%
- SVD orbit + IP-FB: mean $\langle L/L_0\rangle_{train}$=77.84%

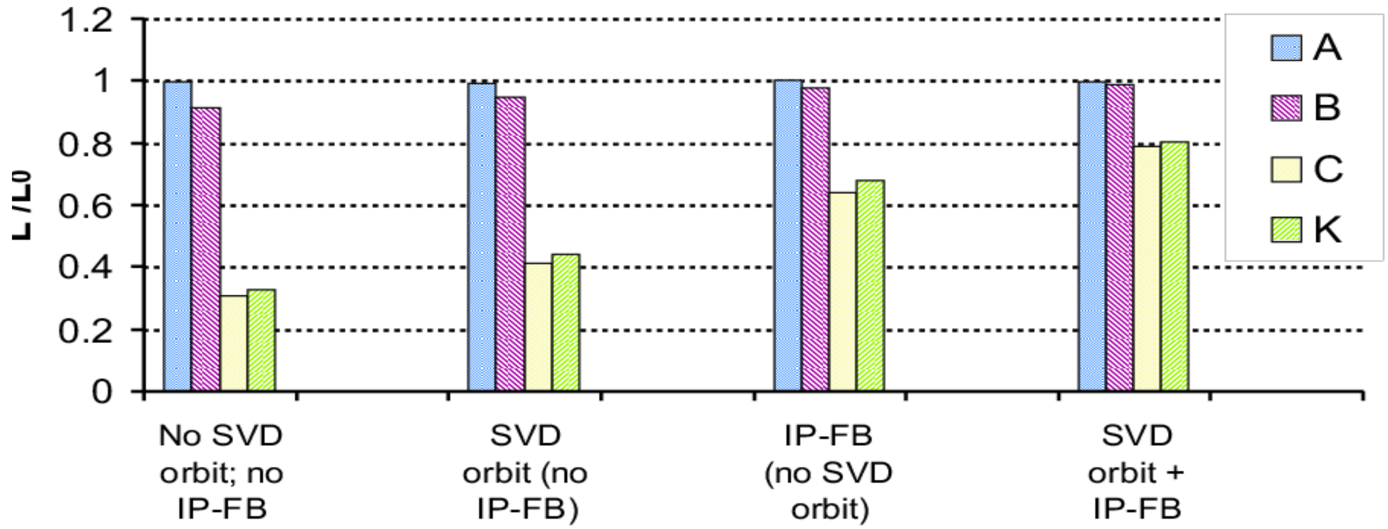
Luminosity result with IP-FB

Different scenarios of ground motion

- Summary of results:



SVD orbit correction BPM resolution ~100 nm



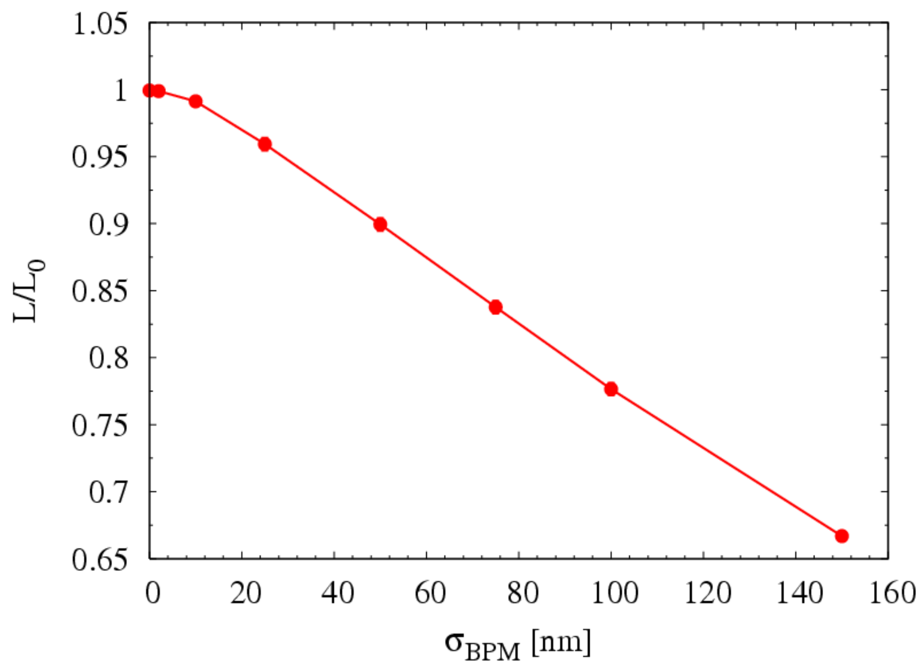
SVD orbit correction BPM resolution ~10 nm

Luminosity performance
Inter-train orbit correction in the BDS

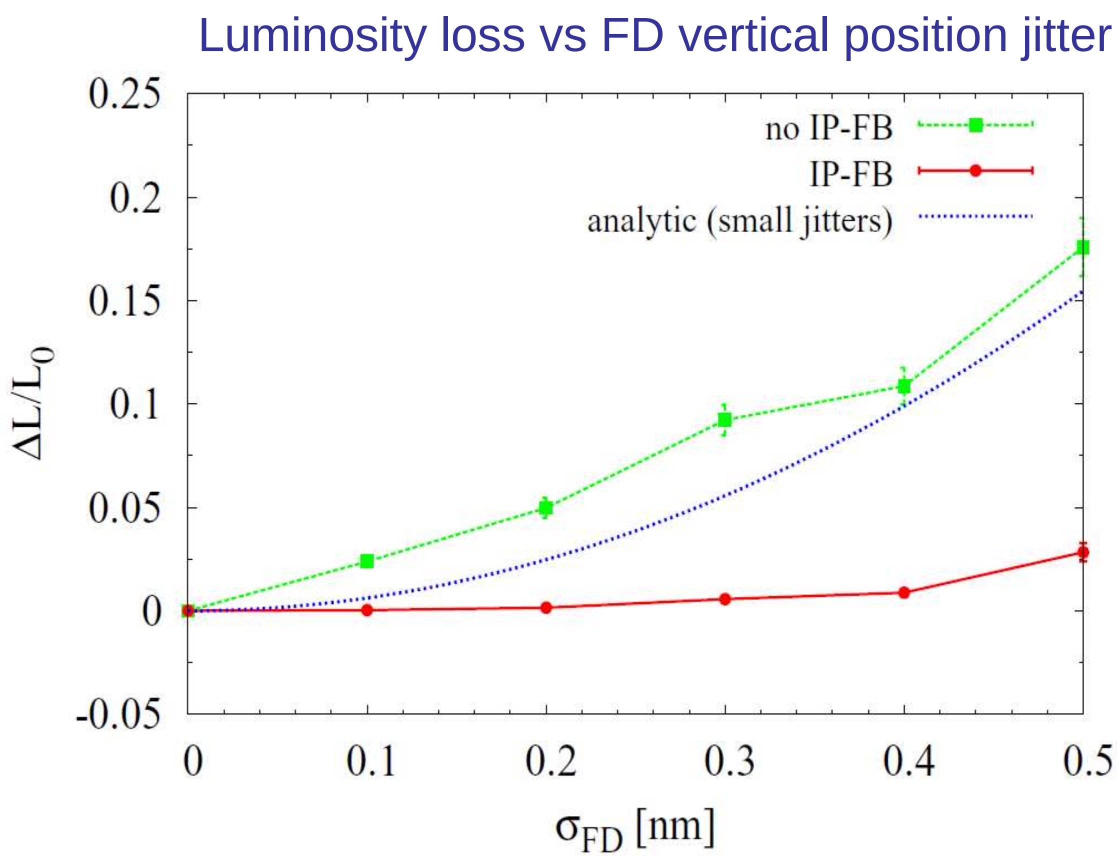
The SVD orbit correction improves the situation with the most severe cases of GM (C & K), but decreases the luminosity (increases the IP-jitter) with the cases of quiet sites (A & B)

The SVD orbit correction limited by the BPM resolution.

- Applying 0.02 s of GM model A (CERN site)
- Orbit correction in the BDS (SVD algorithm) : using the available BPMs and dipole correctors in the BDS lattice
- Relative obtained luminosity versus BPM resolution



FD position jitter tolerance



Points: average over 100 tracking simulations using PLACET + Guinea-Pig

Error bars: std/√100

Without IP-FB correction: $\left\langle \frac{\Delta L}{L_0} \right\rangle > 2\% \quad \text{for} \quad \sigma_{FD} > 0.1 \text{ nm}$

With IP-FB: $\left\langle \frac{\Delta L}{L_0} \right\rangle > 2\% \quad \text{for} \quad \sigma_{FD} > 0.5 \text{ nm}$

Beam stability studies and feedback systems in the CLIC BDS. Plan

- Integrated simulation studies (CERN + JAI collaboration):

  - BDS static misalignment + BBA (1-to-1, DFS): a lot of work already done by A. Latina, D. Schulte and R. Tomas

  - Dynamic imperfections (GM, different scenarios)
  - Additional quadrupole and sextupole position jitters (fast vibrations ~ 50 Hz)
  - Detailed study of tolerances

  - Application of feedback system with different time scales:
    - Pulse-to-pulse
    - Intra-train at the IP (1 iteration every ~74 bunches, possibility to reduce latency ?)