Status report of studies on putting the beams into collisions

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Motivations

- With the actual LHC configuration it would take ~30 to 40s to bring the beams into collisions.

$\Rightarrow$ Optimization of the separation bumps from the optics point of view improved this collapsing time to ~20s. Development to increase the dI/dt of the correctors used could improve this time by another factor 2.

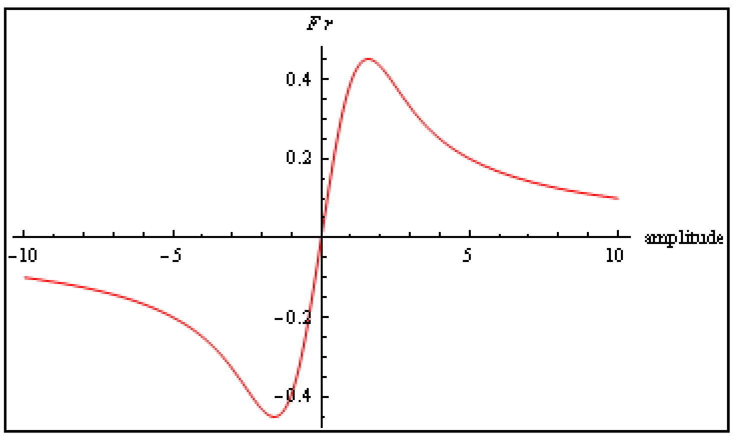
$\Rightarrow$ It is still not sure whether some unwanted effects triggered by the beam-beam interaction would have time to develop.

$\Rightarrow$ Detailed multi-particle tracking required to understand the mechanism that may occur while bringing the beams into collisions.

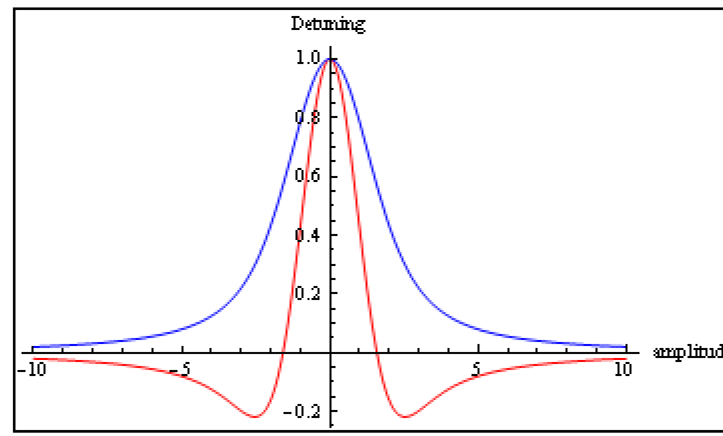
The Beam-Beam Force

The Beam-Beam force for round Gaussian beams can be expressed as:

$$F_r(r) = -\frac{ne^2(1+\beta^2)}{2\pi\varepsilon_0}.\frac{1}{r}.\left[1-\exp\left(-\frac{r^2}{2\sigma^2}\right)\right]$$



Beam-Beam Force for round Gaussian beams.



Non-linear detuning with amplitude normalized to the beam-beam parameter (separation plane in red).

⇒Going through various separations the beams will experience changes in tune and chromaticity.

Tracking code

- A multi-particle strong-strong tracking code was developed for this purpose.

$\Rightarrow$ One turn matrix tracking.

$\Rightarrow$ Soft Gaussian approximation.

$\Rightarrow$ One bunch one IP.

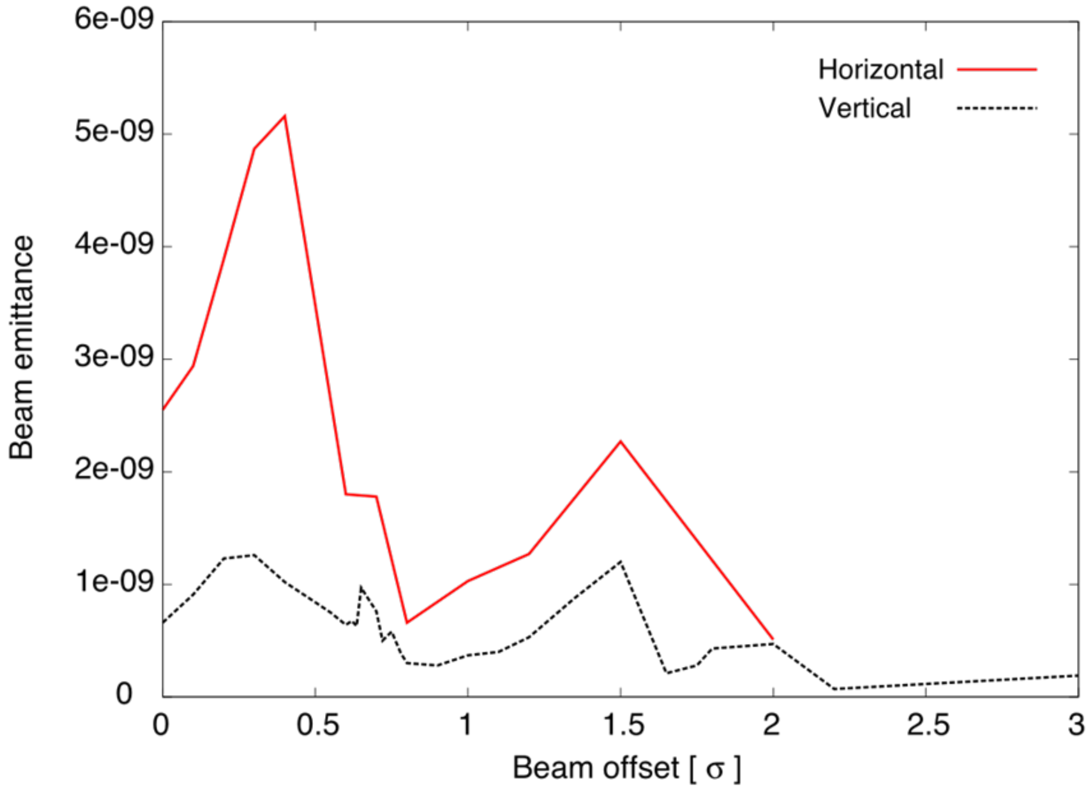
- Possible improvements

$\Rightarrow$ Use the second order map from MadX for the tracking.

$\Rightarrow$ See what would be the effect with more than one IP.

Previous Studies

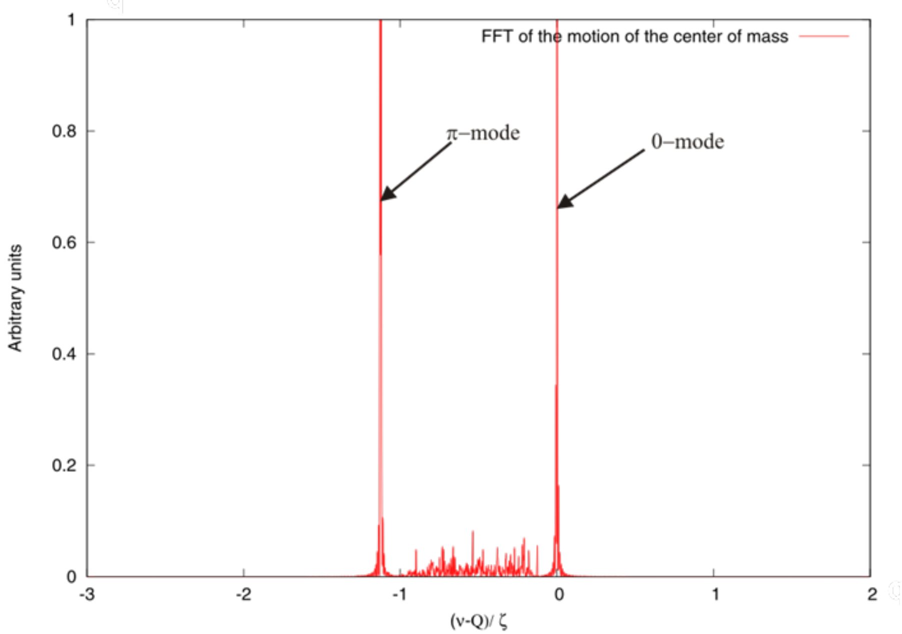
- The study of emittance growth with static offsets was done previously by W. Herr and T. Pieloni.



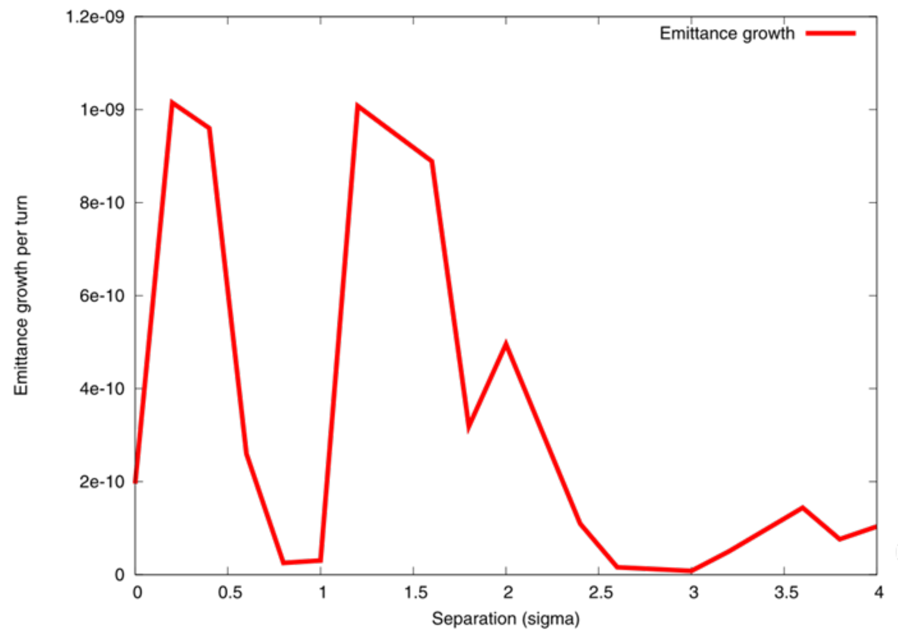
This plot was done with HFMM (arbitrary distribution) and shows a clear dependency between the emittance and the separation. As a comparison I tried to reproduce the same results with the new code.

Results with the new Code

- The code has been tested and seems to give results in good agreement with previous studies.



Frequency analysis of the motion of the center of mass: Yokoya factor ~1.2 (underestimated by Gaussian model)



Emittance growth as function of separation. Static case for 500000 part./500000 turns.

⇒500000 particles instead of 1000000 and the soft Gaussian approximation could explain the differences with the previous plot.

⇒the behavior is similar compared to what was found before.

Conclusions and Future Plans

- Run realistic simulations with the separation varying as a function of time.
- Compare with non-Gaussian case using HFMM (T. Pieloni).
- Look at coherent effects with TRAIN (long range, full LHC).
- Compare all the results and try to give an explanation for the eventual effects.

⇒ A lot of work still needs to be done but all the tools are ready for this study.