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Updates to the CLIC performance studies

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[CLIC European Strategy for Particle Physics performance studies](#)

The CLIC study collaboration proposes new ways of increasing the luminosity performance at 380 GeV at modest additional cost and power consumption. These updates are summarized in a recent CLIC note.



The CLIC study submitted a number of reports to the update of [European Strategy for Particle Physics](#) at the end of 2018, among them a detailed description of the CLIC accelerator complex and its performance. The CLIC project proposes electron-positron collisions in three energy stages: 380, 1500, and 3000 GeV in the center of mass. The baseline scenario for the initial CLIC stage consists of eight years of data taking at 380 GeV accumulating 1.0 ab^{-1} of data.

In subsequent studies, the collaboration has studied ways of increasing the luminosity performance at 380 GeV – by a factor of two to three – at modest additional cost and power consumption. Studies also confirm that high-luminosity running at the Z-pole is possible with a staged installation, or as a dedicated operating period with redistributed modules, and that gamma-gamma collisions at up to 315 GeV are possible with an interesting luminosity spectra for physics. These performance updates are summarized in a recent [CLIC note](#).

Increasing the luminosity at 380 GeV

The CLIC baseline luminosity at 380 GeV is $1.5 \times 10^{34} \text{ cm}^{-2} \text{ s}^{-1}$. The key free parameter for the luminosity is the normalised vertical emittance ϵ_y at the interaction point (IP). The value of ϵ_y at the damping ring extraction is 5 nm, and a growth to 30 nm during the transport to the IP, due to various imperfections, has been taken into account for in the luminosity predictions. Considering only static imperfections, the luminosity would be $1.9 \times 10^{34} \text{ cm}^{-2} \text{ s}^{-1}$; simulations of the expected performance show more than $2.3 \times 10^{34} \text{ cm}^{-2} \text{ s}^{-1}$ with a 90% likelihood and an average value of $3.0 \times 10^{34} \text{ cm}^{-2} \text{ s}^{-1}$. A machine without imperfections would reach a luminosity of $4.3 \times 10^{34} \text{ cm}^{-2} \text{ s}^{-1}$. Future improvements of the technologies to mitigate imperfections, e.g. better pre-alignment and active stabilisation systems, will allow to come closer to this value. A machine without imperfections would reach a luminosity of $4.3 \times 10^{34} \text{ cm}^{-2} \text{ s}^{-1}$. Future improvements of the accelerator technologies to mitigate imperfections – e.g. better pre-alignment and active stabilisation systems – will allow to come closer to such a value.

An important outcome of the technical studies made for the European Strategy update concerning the 380 GeV initial energy stage was the realization that the repetition rate of the facility, and consequently its luminosity, could be doubled, from 50 Hz to 100 Hz, without major changes and with relatively little increase in the overall power consumption. This is because a large fraction of the power is used by systems where the consumption is independent of the repetition rate. Specifically, even though the power required by the RF systems increases by about a factor two, the total power consumption only increases from 170 to 220 MW, that is, around 30%. The associated cost increase must be evaluated in detail, but it is expected to be approximately 5%. Some components of the collider would require minor design modifications, and these are well understood. Specifically, a special study verified that we can control the impact of the stray fields will be larger at 100 Hz.

Running CLIC at the Z-pole

Operating the 380 GeV CLIC accelerator complex at the Z-pole results in an expected luminosity of about $L = 2.3 \times 10^{32} \text{ cm}^{-2} \text{ s}^{-1}$. In this scenario, the main linac gradient is reduced by about a factor of four, leaving the rest of the configuration. On the other hand, an initial installation of the linac modules needed for a Z-pole factory, and an appropriately adapted beam delivery system, would result in a luminosity of $L = 0.36 \times 10^{34} \text{ cm}^{-2} \text{ s}^{-1}$ for a 50 Hz operation. This option is worthwhile if one would operate for a couple of years at the Z-

pole, at the beginning or end of the first energy stage.

Gamma-gamma collisions at 380 GeV

Recent studies have also revealed the potential of operating the CLIC linear collider in gamma-gamma mode, providing additional physics possibilities. In this mode, two electron beams are focused at the interaction point, but just before it an intense laser pulse collides with each beam. The electrons will Compton-scatter photons in the direction of the collision point, typically carrying 80% of the beam energy. The expected 80% electron polarization is important for this process. An example of a gamma-gamma luminosity spectrum for the 380 GeV stage is shown in figure 1.

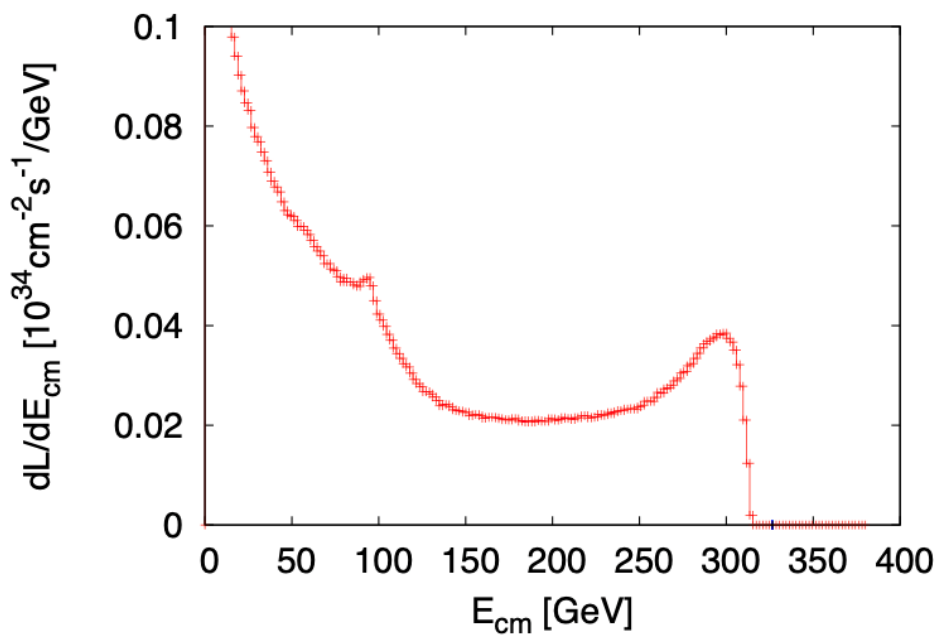


Figure 1: Example of a gamma-gamma luminosity spectrum that can be obtained with CLIC.

The luminosities discussed above can be delivered to one detector as in the baseline CLIC scenario, or shared on two detectors using either push-pull technology, or by constructing a second beam delivery system and interaction point. However, the latter would add substantially to the costs (? 15%) of the accelerator project.

Further technical details about these studies can be found in the recent CLIC study update:

1. CLIC-Note-1143: CLIC study update August 2019: <http://cds.cern.ch/record/2687090>