LCWS2015 | International Workshop on Future Linear Colliders

CLIC rebaselining and long L* study

BDS designs from 380 GeV to 3 TeV with L*=6 m

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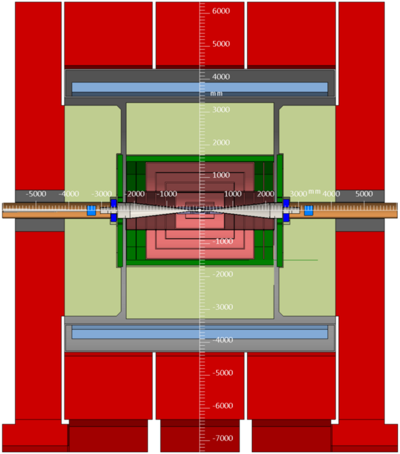
OUTLINES

Long L* study

Motivations : No interplays between the solenoid field and QD0 field (no anti-solenoid needed), reduces QD0 vibration, eases stabilization and acess to QD0, better forward acceptance ?

picture from N. Siegrist



- New detector model **CLICdet-2015** under study ⇒ allows to remove QD0 from the experiment (single detector, no push-pull) with L^* = 6 m
- Serie of meetings aiming to define the MDI element positions, the detector and cavern layout, impact and limit on foward acceptance and so forth.
- BDS optimization in order to identify the potential performances (loss of luminosity compare to the nominal L^*), pre-alignment and tuning performance and impact of the detector field on luminosity

Rebaselining

Goal :

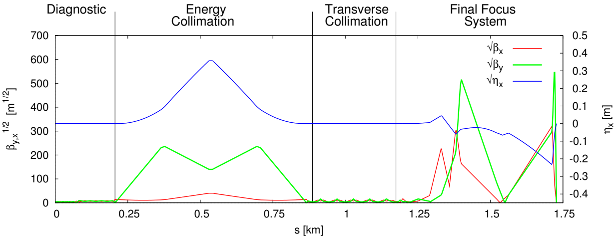
- Optimization of the BDS optics starting from the CLIC 500 GeV baseline (For L^*= 4.3 m and L^*= 6 m)
- FFS scheme based on the Local Chromaticity Correction
- Definition of the machine parameters at 380 GeV
- Dispersion optimization in the FFS for both options (nominal and long L^*) in order to improve chromaticity correction
- Energy transition from CLIC 380 GeV to 3 TeV c.o.m :
  - Alignment of the CLIC 380 GeV Linac with the CLIC 3 TeV Linac in the tunnel $\Rightarrow$ Changes of the angles of the energy collimation bending magnets and crossing angle
  - Re-optimization of the final lattice and comparative study between both options

Design parameters

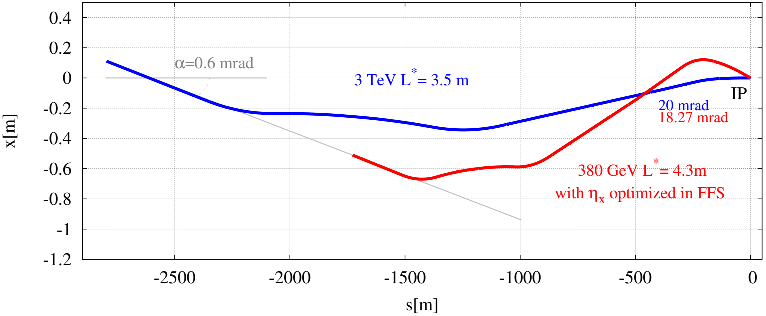
CLIC	380 GeV	380 GeV
L^* (m)	**4.3**	**6**
FFS length (m)	553	770
$\epsilon_{Nx}/\epsilon_{Ny}$ (nm)	950 / 20	950 / 20
β^*_x/β^*_y (mm)	8.2 / 0.1	8.2 / 0.1
σ^*_x/σ^*_y design (nm)	145 / 2.32	145 / 2.32
σ_z (μm)	70	70
δ_p (%)	0.3	0.3
particles/bunch N ($\times 10^9$)	5.2	5.2
Number of bunches n_b	352	352
f_{rep} (Hz)	50	50
L_{tot} ($10^{34}cm^{-2}s^{-1}$)	**1.5**	**1.5**
$L_{1\%}$ ($10^{34}cm^{-2}s^{-1}$)	**0.9**	**0.9**
Chromaticity ξ_y (L^*/β^*_y)	43000	60000

- CLIC 380 GeV emittances $\epsilon_{x,y}$ were chosen according to the emittances calculated at the exit of the Main Linac

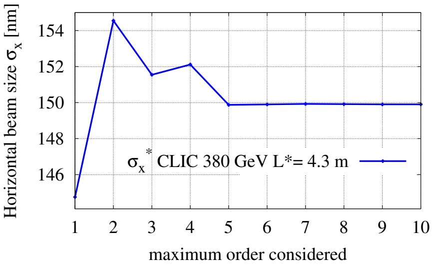
CLIC 380 GeV BDS with L*=4.3 m

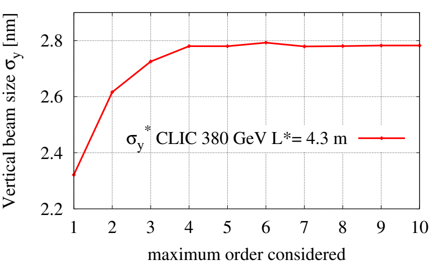


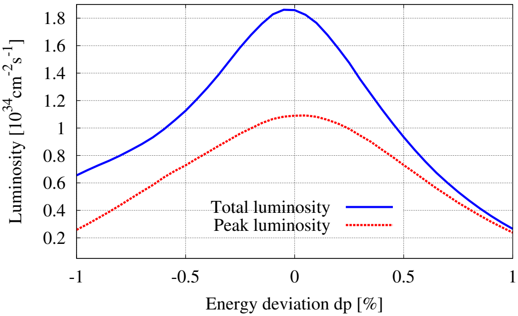
- Scan of the dispersion done ⇒ no change in the FFS bending magnets was needed
- Alignment of the Linacs performed only by reducing the crossing angle from 20mrad to **18.27 mrad**
- No change in the energy collimation bending magnets was needed



CLIC 380 GeV BDS with L*=4.3 m





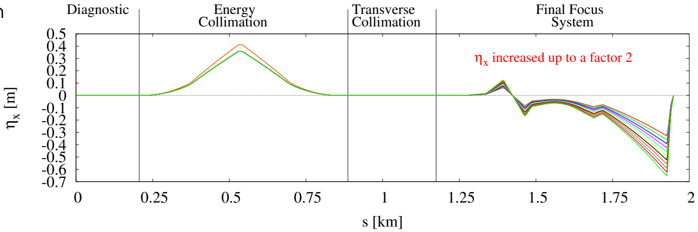


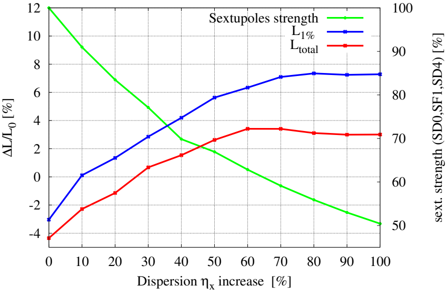
σ_x^*/σ_x^*(SR) (nm)	149.5 / **150**
σ_y^*/σ_y^*(SR) (nm)	2.78 / **2.7**
L_{tot} $(10^{34}cm^{-2}s^{-1})$	**1.86**
$L_{1\%}$ $(10^{34}cm^{-2}s^{-1})$	**1.09**

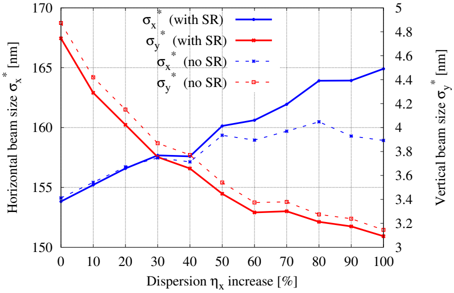
- The total luminosity achieved is **24%** higher than the design one and **21%** for the luminosity in the peak
- Very small impact of synchrotron radiation at low energy

CLIC 380 GeV BDS with L*=6 m

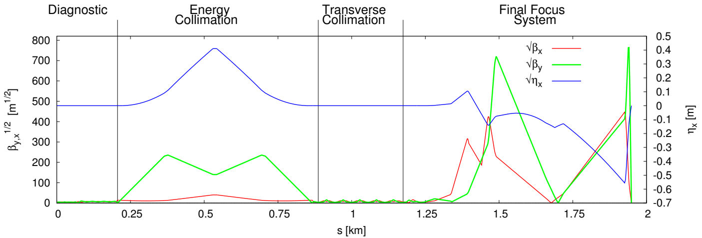
- The optimal dispersion η_x was found by **increasing the dipole angles by 70%**
- With the optimal dipole angles the average sextupole strength have been reduced by 40%



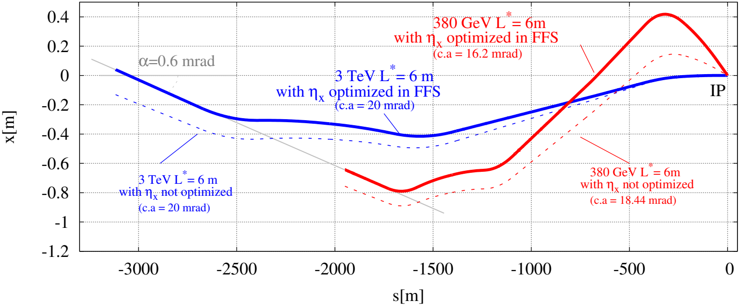




CLIC 380 GeV BDS with L*=6 m

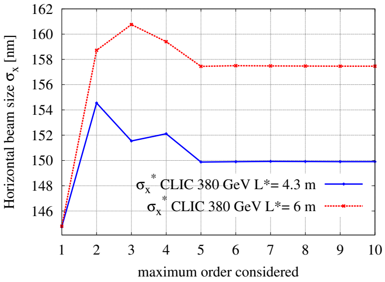


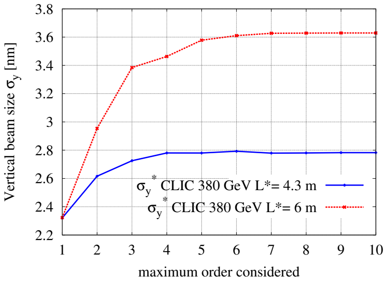
- Functions $\beta_{x,y}$ and η_x with FFS bendings increased by 70% and EC bendings modified
- Alignment of the Linacs performed by reducing c.a to **16.2 mrad** and increasing EC bendings by 15%

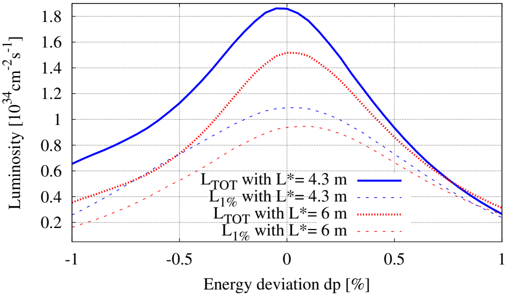


- The optimized CLIC 380 GeV BDS ($L^* = 6m$) is aligned in the tunnel with the optimized CLIC 3 TeV BDS with $L^* = 6m$ (shown in the next slides)

Performances : L* = 4.3 m vs L* = 6 m







σ_x^*/σ_x^*(SR) (nm)	157 / **160**
σ_y^*/σ_y^*(SR) (nm)	3.6 / **3.5**
L_{tot} $(10^{34}cm^{-2}s^{-1})$	**1.52**
$L_{1\%}$ $(10^{34}cm^{-2}s^{-1})$	**0.94**

- Luminosity of the optimized and aligned system
- **1.5%** in L_{tot} and **4.5%** in $L_{1\%}$ of luminosity budgets
- The changes in EC bendings leads to 2% of L_{tot} loss and 3.2% of $L_{1\%}$

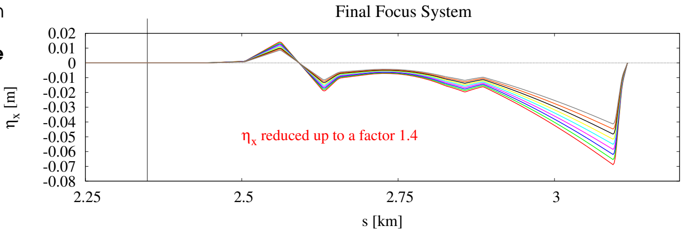
Design parameters CLIC 3 TeV

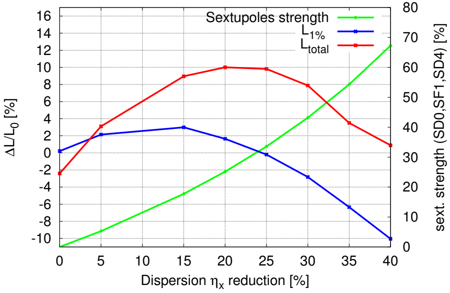
CLIC	**3 TeV**	**3 TeV**
L^* (m)	**3.5**	**6**
FFS length (m)	553	770
$\epsilon_{Nx}/\epsilon_{Ny}$ (nm)	660 / 20	660 / 20
β_x^*/β_y^* (mm)	**7 / 0.068**	**7 / 0.1**
σ_x^*/σ_y^* design (nm)	40 / 0.7	40 / 1
σ_z (μm)	44	44
δ_p (%)	0.3	0.3
particles/bunch N ($\times 10^9$)	3.72	3.72
Number of bunches n_b	312	312
f_{rep} (Hz)	50	50
L_{tot} ($10^{34} cm^{-2} s^{-1}$)	**5.9**	**5.9**
$L_{1\%}$ ($10^{34} cm^{-2} s^{-1}$)	**2**	**2**
Chromaticity ξ_y (L^*/β_y^*)	51500	60000

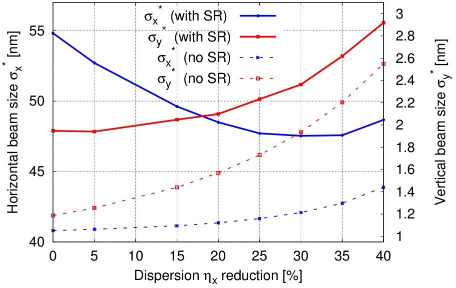
- For the L^* = 6 m option an optimization study of the $\beta^*_{x,y}$ have been performed in order to optimize the luminosity
- The β_y^* have been increased from 0.068 mm to 0.1 mm allowing to reduce the chromaticity at the IP and reduce the β_y function at the Final Doublet

Optimisation of the beamline with L*=6 m

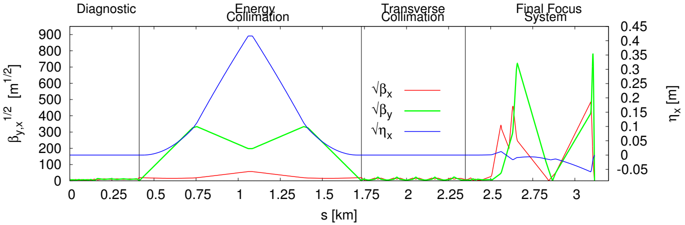
- The optimal dispersion η_x was found by **decreasing the dipole angles by 15%**
- With the optimal dipole angles the average sextupole strength have been increased by 18%



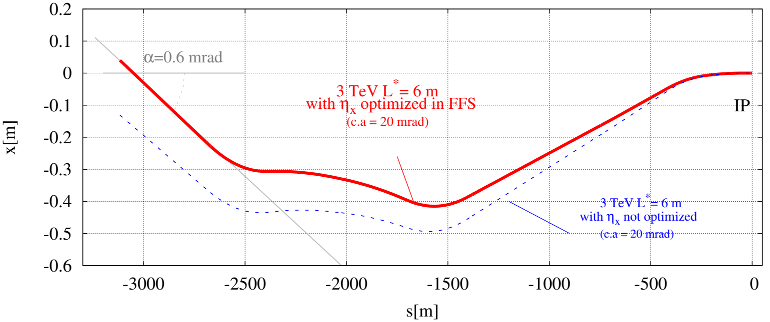




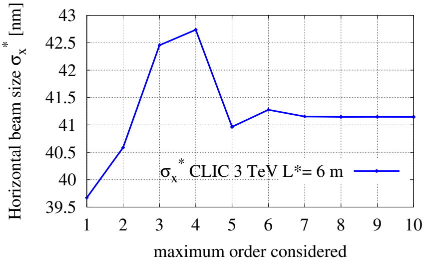
Optimisation of the beamline with L*=6 m

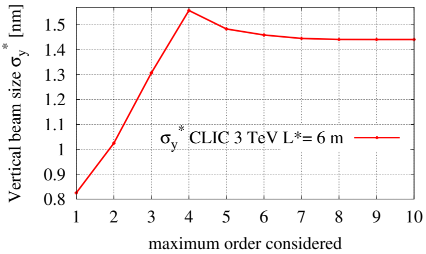


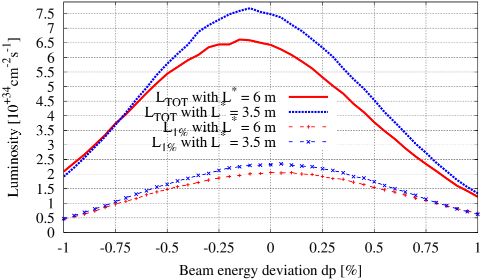
- Functions $\beta_{x,y}$ and η_x with FFS bendings decreased by 15%
- Footprint of the BDS in the tunnel for L^*=6m before and after η_x optimization in the FFS



Performances : L* = 3.5 m vs L* = 6 m





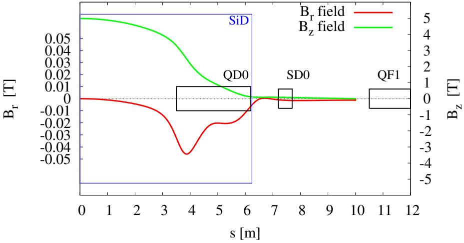


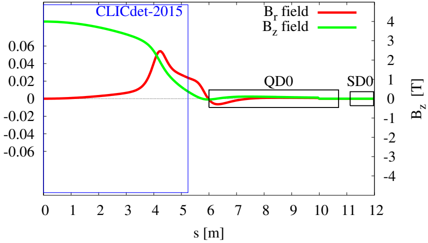
L^* (m)	6	3.5
σ_x^*/σ_x^*(SR) (nm)	41.2 / **49.7**	40 / **47.7**
σ_y^*/σ_y^*(SR) (nm)	1.44 / **2**	1 / **2.5**
L_{tot} $(10^{34}cm^{-2}s^{-1})$	**6.43**	**7.5**
$L_{1\%}$ $(10^{34}cm^{-2}s^{-1})$	**2.06**	**2.3**
Budget $L_{tot}/$ $L_{1\%}$ (%)	9 / 3	27 / 15

- The luminosity loss by increasing L^* from 3.5 m to 6 m is **14%** in L_{tot} and **10%** in $L_{1\%}$
- No octupoles were inserted in the L^* = 6 m beamline

Impact on CLIC 3 TeV luminosity

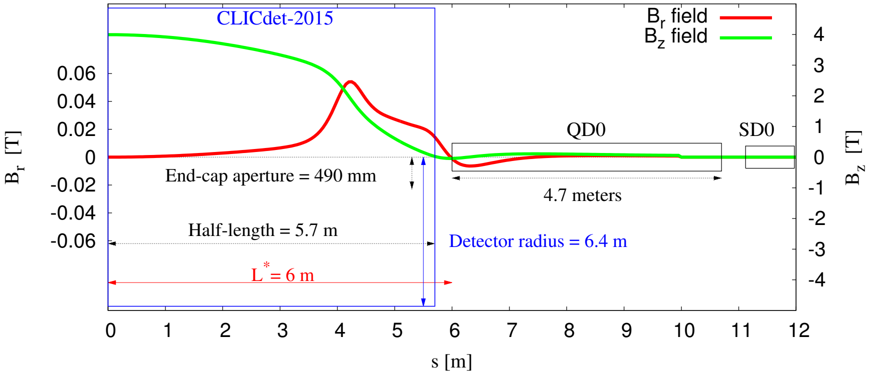
(B_z and B_r fields evaluated along the beamline (20mrad crossing angle) in the solenoid reference frame)





- B_z and B_r fields of the SiD solenoid with the last magnets of the L^*=3.5m lattice (left plot) and of the new detector model CLICdet-2015 simulated by *B. Curé* with the last magnets of the L^*=6m lattice (right plot)
- The simulation approach has been implemented and applied on the nominal 3 TeV BDS with the SiD detector by *B. Dalena* and *Y. Levinsen* (***Phys. Rev. ST Accel. Beams 17, 051002 (2014)***)
- The same simulation process using PLACET and GUINEA-PIG have been applied on the L^* = 6 m lattices with the field of the CLICdet-2015
- The simulation procedure evaluates the **luminosity loss due to ISR** in the interaction region

Impact on CLIC 3 TeV luminosity



CLIC 3 TeV	Impact on L_{TOT} (%)	Impact on L_{peak} (%)
L^*= **6 m** NO Antisol	**3.7**	**4.6**
L^*= **3.5 m** NO Antisol	**7.8**	**8.2**
L^*= **3.5 m** WITH Antisol	**6.25**	**6.7**

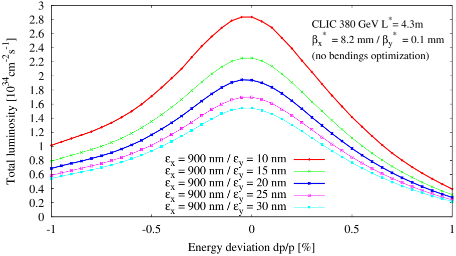
Summary

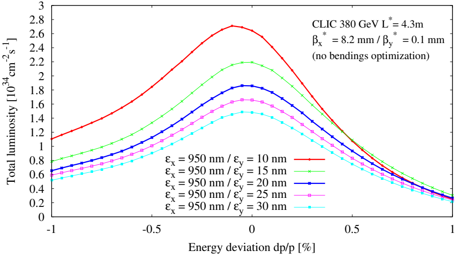
CLIC	380 GeV	380 GeV	3 TeV	3 TeV
L^* (m)	**4.3**	**6**	**3.5**	**6**
σ_x^* (SR) (nm)	150	160	47.7	49.7
σ_y^* (SR) (nm)	2.7	3.5	2.5	2
L_{tot} (design) / L_{tot} $(10^{34} cm^{-2} s^{-1})$	1.5 / **1.86**	1.5 / **1.52**	5.9 / **7.5**	5.9 / **6.43**
$L_{1\%}$ (design) / $L_{1\%}$ $(10^{34} cm^{-2} s^{-1})$	0.9 / **1.09**	0.9 / **0.94**	2 / **2.3**	2 / **2.06**
Chromaticity ξ_y (computed)	68464	95697	82637	93017
Budget L_{tot}/ $L_{1\%}$ (%)	24 / 21	1.5 / 4.5	27 / 15	9 / 3
Impact of solenoid on L_{tot}/ $L_{1\%}$ (%)	-	-	**7.8 / 8.2**	**3.7 / 4.6**
Tuning performances	-	-	-	-

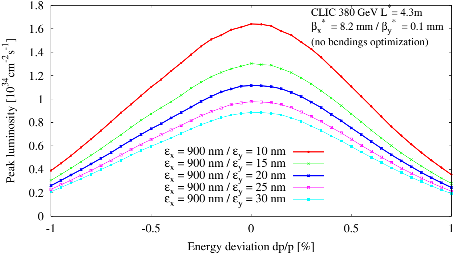
- All lattices fulfill now the design performance requirements
- For L^*= 6m option for each stage, the luminosity budget for static and dynamic imperfections is low
- The impact of the solenoid on the luminosity is lower for the long L^* option and should not require anti-solenoid
- The tuning is still on progress and will be decisive for the final layout of the FFS (Tradition or Local scheme ? Short or long L^* ?)

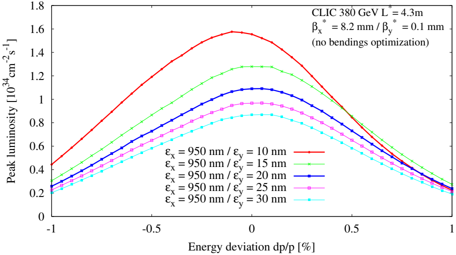
BACK UP

Emittances scan for CLIC 380 GeV with L*= 4.3 m









Emittances scan for CLIC 380 GeV with L*= 4.3 m

warning : red lines are ϵ_x = 950 nm and blue lines are ϵ_x = 900 nm