# CLIC accelerator complex (2012)

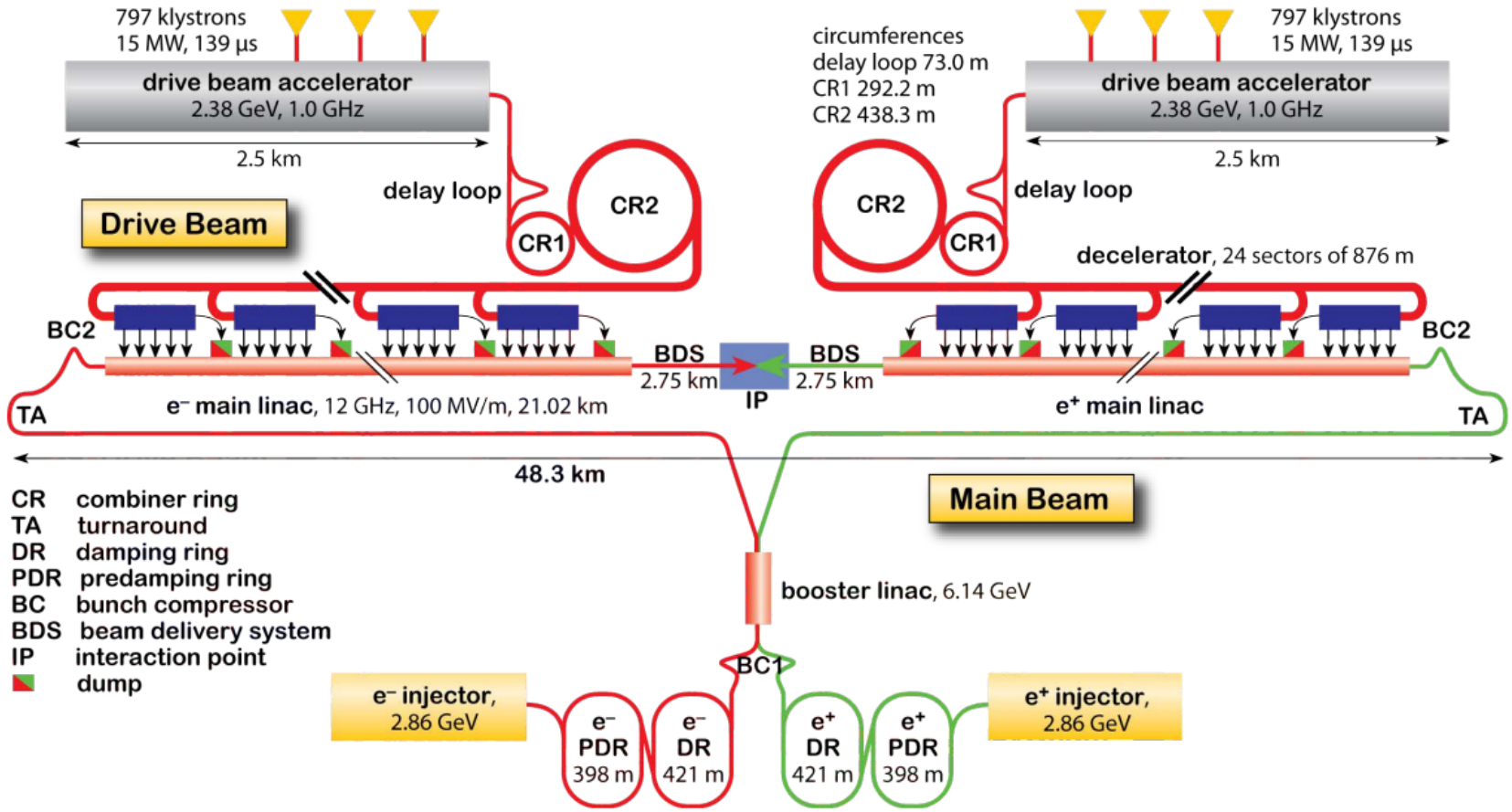



**Fig. 2.1:** CLIC layout at 3 TeV

# CLIC accelerator complex (2018)

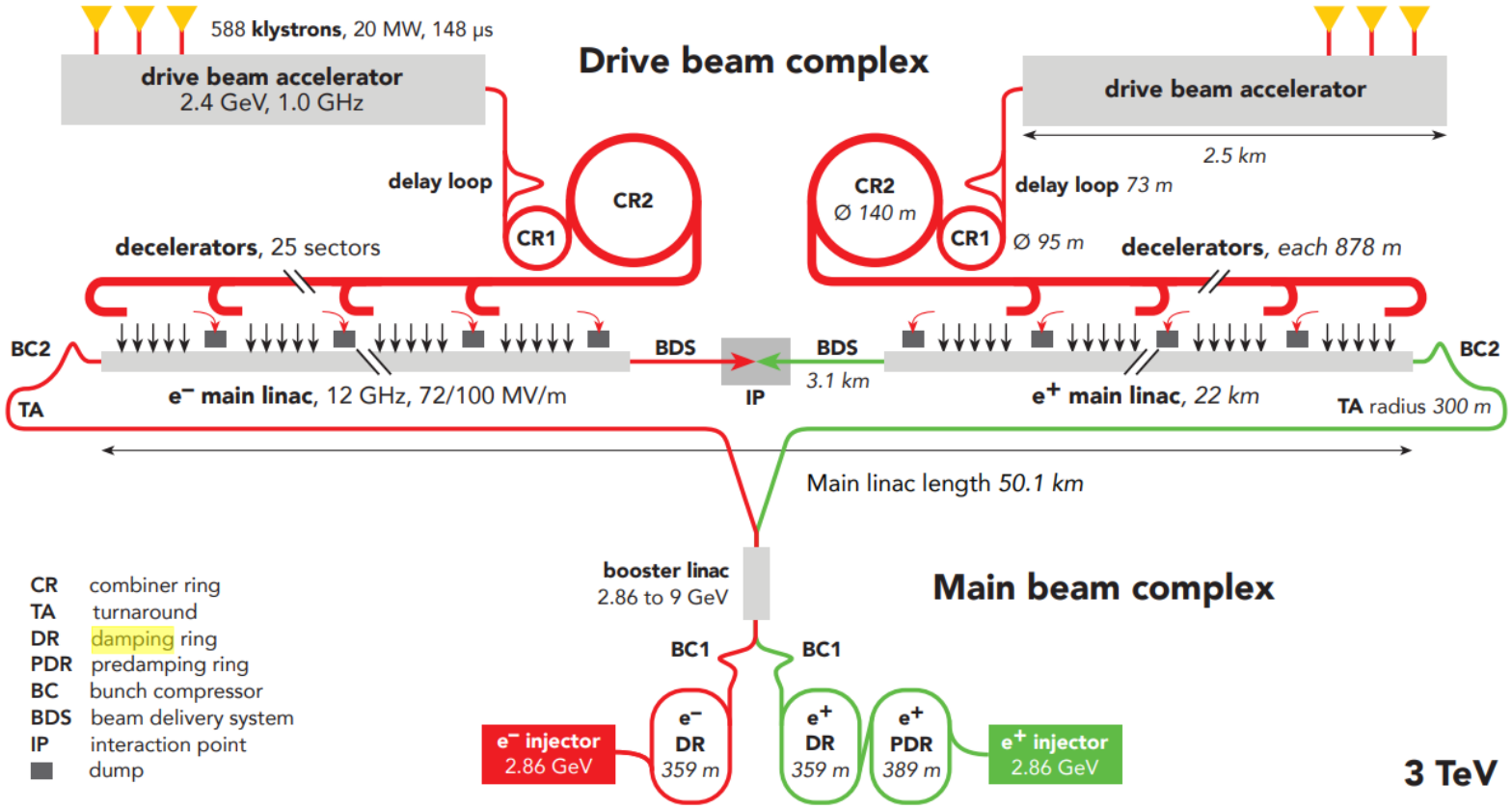
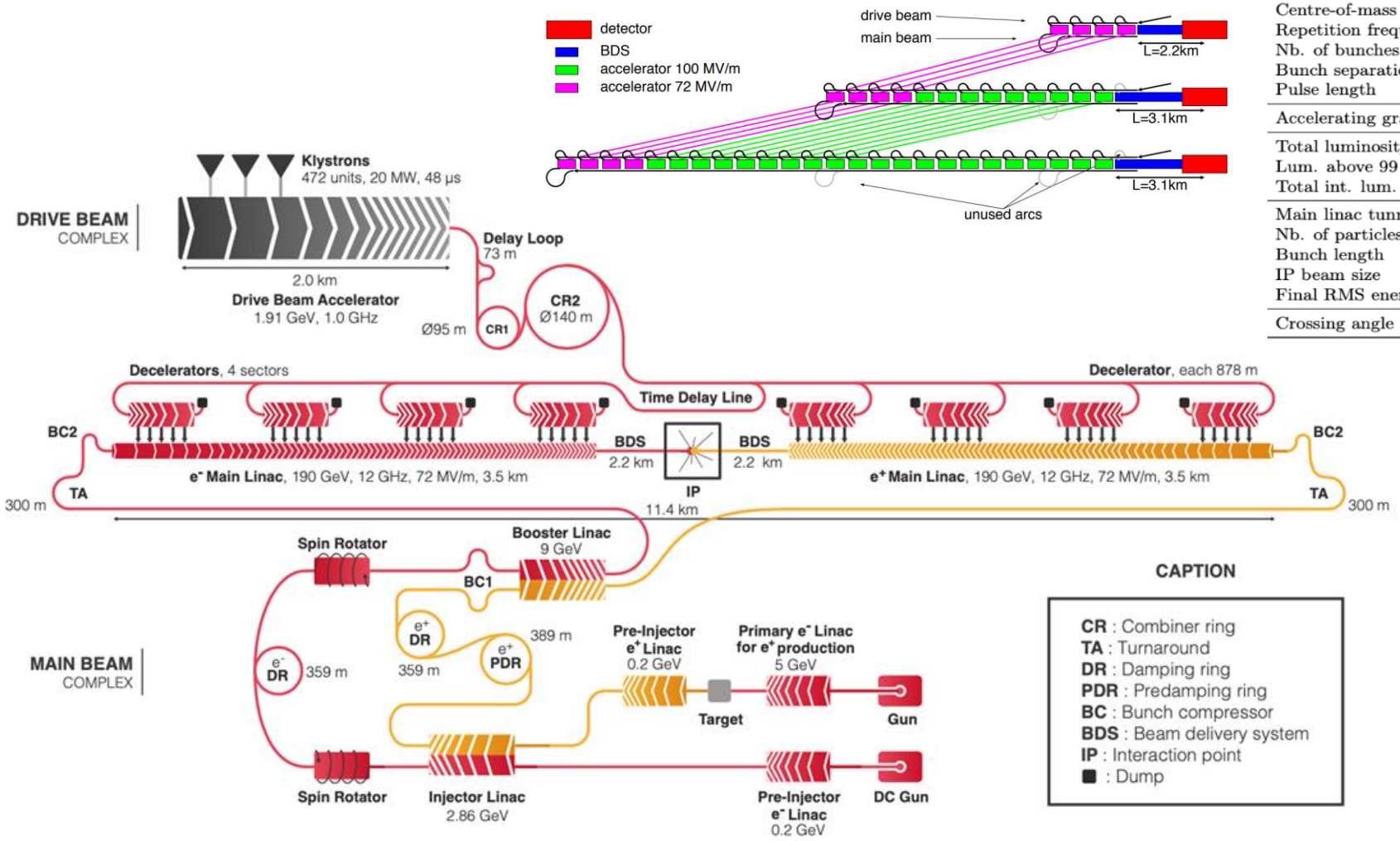



Figure 16: Schematic layout of the CLIC complex at 3 TeV. (image credit: CLIC)

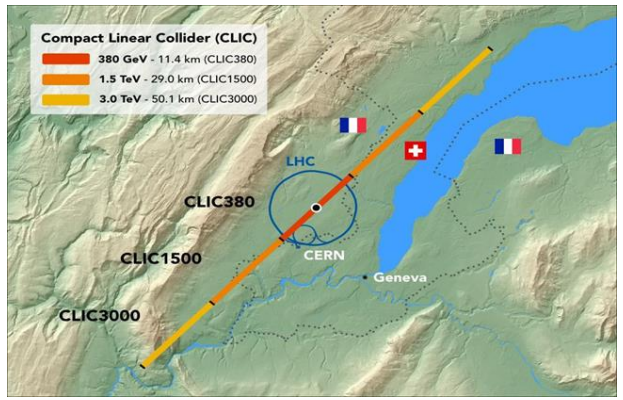
# CLIC accelerator complex (380GeV)




| Parameter | Unit | Stage 1 | Stage 2 | Stage 3 |
|---|---|---|---|---|
| Centre-of-mass energy | GeV | 380 | 1500 | 3000 |
| Repetition frequency | Hz | 50 | 50 | 50 |
| Nb. of bunches per train | | 352 | 312 | 312 |
| Bunch separation | ns | 0.5 | 0.5 | 0.5 |
| Pulse length | ns | 244 | 244 | 244 |
| Accelerating gradient | MV/m | 72 | 72/100 | 72/100 |
| Total luminosity | $1\times10^{34}\,\mathrm{cm}^{-2}\,\mathrm{s}^{-1}$ | 2.3 | 3.7 | 5.9 |
| Lum. above 99 % of $\sqrt{s}$ | $1\times10^{34}\,\mathrm{cm}^{-2}\,\mathrm{s}^{-1}$ | 1.3 | 1.4 | 2 |
| Total int. lum. per year | $\mathrm{fb}^{-1}$ | 276 | 444 | 708 |
| Main linac tunnel length | km | 11.4 | 29.0 | 50.1 |
| Nb. of particles per bunch | $1\times10^{9}$ | 5.2 | 3.7 | 3.7 |
| Bunch length | μm | 70 | 44 | 44 |
| IP beam size | nm | 149/2.0 | ∼60/1.5 | ∼40/1 |
| Final RMS energy spread | % | 0.35 | 0.35 | 0.35 |
| Crossing angle (at IP) | mrad | 16.5 | 20 | 20 |

**CAPTION**

**CR** : Combiner ring
**TA** : Turnaround
**DR** : Damping ring
**PDR** : Predamping ring
**BC** : Bunch compressor
**BDS** : Beam delivery system
**IP** : Interaction point
■ : Dump



# CLIC versus ILC and NLC parameters driving the damping ring design

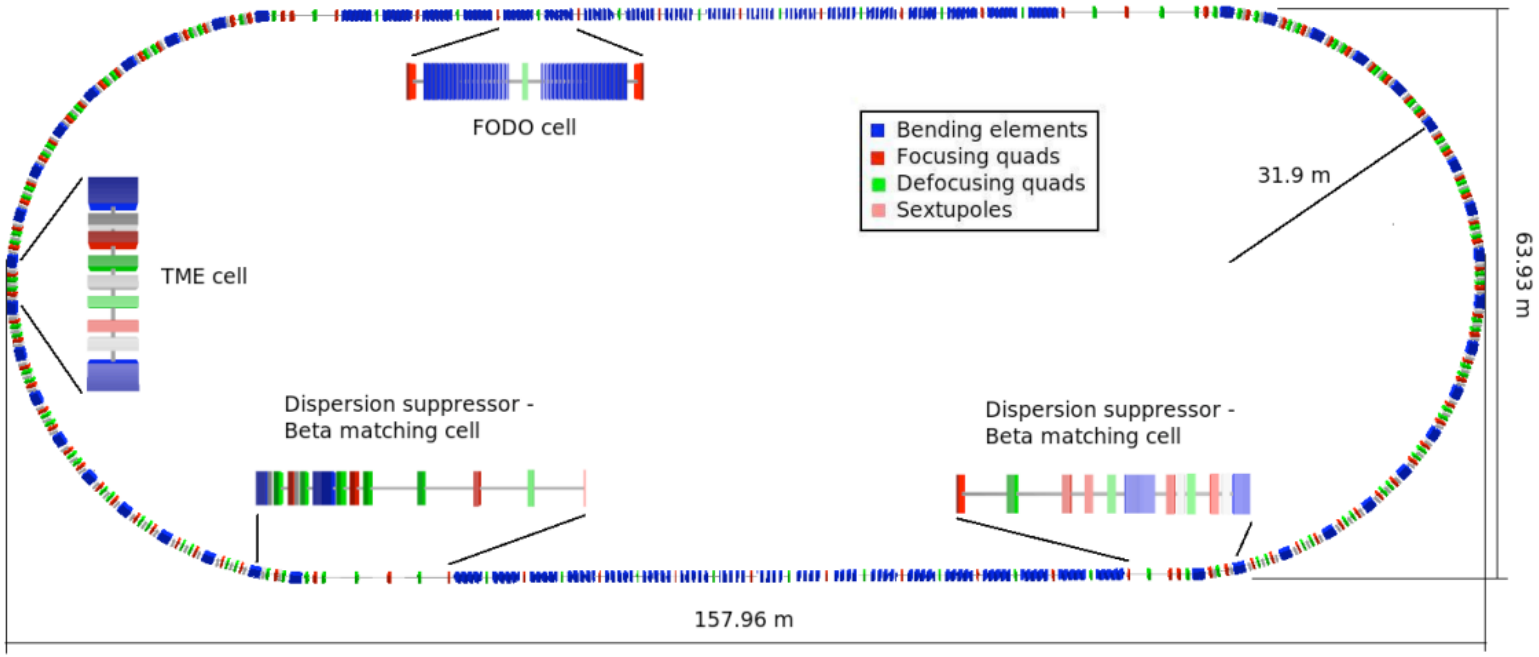
- Creation of ultra-low emittance beams

| **Parameters** [units] | **ILC** | **NLC** | **CLIC** |
|---|---|---|---|
| Bunch population [$10^9$] | 20 | 7.5 | 4.1 |
| Bunch spacing [ns] | 369 | 1.4 | 0.5 |
| Number of bunches/train | 2625 | 192 | 312 |
| Number of trains | 1 | 3 | 1 |
| Repetition rate [Hz] | 5 | 120 | 50 |
| Horizontal normalized emittance [nm] | 4400 | 2400 | 500 |
| Vertical normalized emittance [nm] | 20 | 30 | 5 |
| Longitudinal normalized emittance [keV.m] | 38 | 11 | 6 |

# Beam parameters at the exit of the low energy linac and before injection to the pre-damping rings

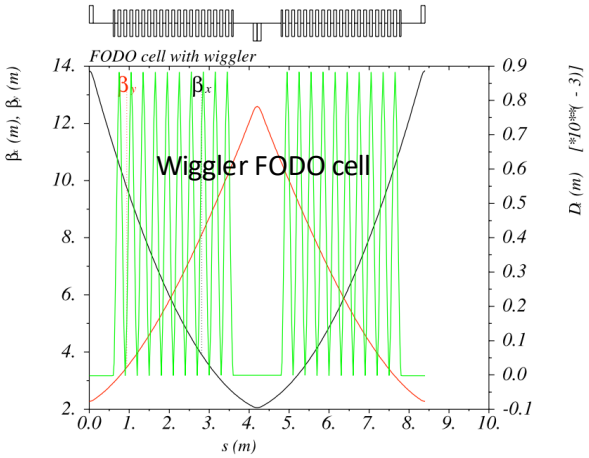
| **Injected parameters** | $\mathbf{e^-}$ | $\mathbf{e^+}$ |
|---|---|---|
| Bunch population [$10^9$] | 4.3 | 6.6 |
| r.m.s. Bunch length [mm] | 4 | 5.4 |
| r.m.s. Energy spread [%] | 1 | 4.5 |
| Hor., Ver. Norm. emittance [nm] | $100\times10^3$ | $7\times10^6$ |

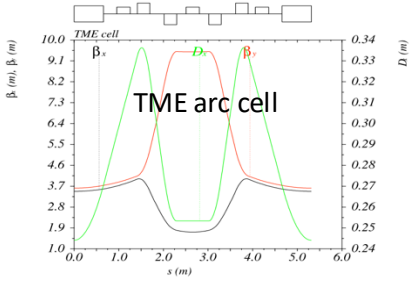
# CLIC pre-damping ring



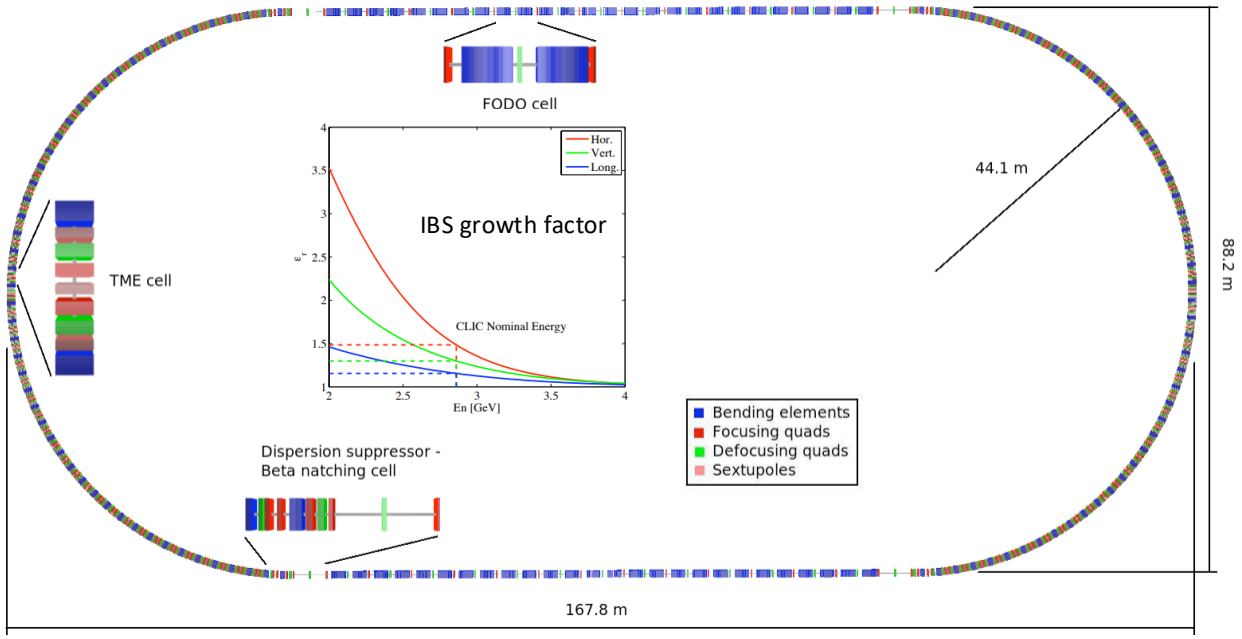

| Parameter, Symbol [Unit] | 2 GHz | 1 GHz |
|---|---|---|
| Energy, $E$ [GeV] | 2.86 | |
| Circumference, $C$ [m] | 389.15 | |
| Bunch population, $N$ [$10^9$] | 4.3 | |
| Basic cell type in the arc/LSS | TME/FODO | |
| Number of dipoles, $N_d$ | 38 | |
| Dipole Field, $B_0$ [T] | 1.2 | |
| Horizontal and vertical tune, ($Q_x$,$Q_y$) | (16.39,12.26) | |
| Horizontal and vertical chromaticity, ($\xi_x$,$\xi_y$) | (-19.0,-22.9) | |
| Number of wigglers, $N_w$ | 36 | |
| Wiggler peak field, $B_w$ [T] | 1.9 | |
| Wiggler length, $L_w$ [m] | 3 | |
| Wiggler period, $\lambda_w$ [cm] | 30 | |
| Norm. equil. horizontal emittance, $\gamma\varepsilon_{x0}[\mu m]$ | 54 | |
| Hor., vert. and long. damping time, ($\tau_x$, $\tau_y$, $\tau_l$) [ms] | (2.7,2.7,1.35) | |
| Momentum compaction factor, $\alpha_c$ [$10^{-3}$] | 3.7 | |
| Energy loss/turn, $U$ [MeV] | 2.8 | |
| Equil. energy spread (r.m.s.), $\sigma_\delta$ [%] | 0.1 | |
| RF Voltage, $V_{RF}$ [MV] | 10 | |
| Synchrotron tune, $Q_s$ | 0.071 | 0.051 |
| Bunches per train, $n_b$ | 312 | 156 |
| Bunch spacing, $\tau_b$ [ns] | 0.5 | 1 |
| RF acceptance, $\varepsilon_{RF}$ [%] | 1.2 | 1.7 |
| Harmonic number, $h$ | 2596 | 1298 |
| Equil. bunch length (r.m.s.), $\sigma_s$ [mm] | 3.2 | 4.6 |

| Parameters | Injected $e^-$ | Injected $e^+$ | Extracted |
|---|---|---|---|
| Bunch population [$10^9$] | 4.3 | 4.3 | 4.3 |
| r.m.s. bunch length [mm] | 4 | 5.4 | 10 |
| r.m.s. energy spread [%] | 1 | 0.6 | 0.5 |
| Long. emittance [keV.m] | 114 | 93 | 143 |
| Hor. Norm. emittance [$\mu$m] | 100 | $7\times10^3$ | 63 |
| Ver. Norm. emittance [$\mu$m] | 100 | $7\times10^3$ | 1.5 |



# CLIC main damping ring




| Parameters, Symbol [Unit] | 2 GHz | 1 GHz |
|---|---|---|
| Energy, $E$ [GeV] | 2.86 | |
| Circumference, $C$ [m] | 427.5 | |
| Bunch population, $N$ [$10^9$] | 4.1 | |
| Basic cell type in the arc/LSS | TME/FODO | |
| Number of dipoles, $N_d$ | 100 | |
| Dipole Field, $B_0$ [T] | 1.0 | |
| Norm. gradient in dipole [$m^{-2}$] | -1.1 | |
| Horizontal and vertical tune, $(Q_x,Q_y)$ | (48.35,10.40) | |
| Horizontal and vertical chromaticity, $(\xi_x,\xi_y)$ | (-115,-85) | |
| Number of wigglers, $N_w$ | 52 | |
| Wiggler peak field, $B_w$ [T] | 2.5 | |
| Wiggler length, $L_w$ [m] | 2 | |
| Wiggler period, $\lambda_w$ [cm] | 5 | |
| Hor., vert. and long. damping time, $(\tau_x, \tau_y, \tau_l)$ [ms] | (2.0,2.0,1.0) | |
| Momentum compaction factor, $\alpha_c$ [$10^{-4}$] | 1.3 | |
| Energy loss/turn, $U$ [MeV] | 4.0 | |
| Norm. horizontal emittance, $\gamma\varepsilon_x$ [nm] | 472 | 456 |
| Norm. vertical emittance, $\gamma\varepsilon_y$ [nm] | 4.8 | 4.8 |
| Energy spread (r.m.s.), $\sigma_\delta$ [%] | 0.1 | 0.1 |
| Bunch length (r.m.s.), $\sigma_s$ [mm] | 1.6 | 1.8 |
| Longitudinal emittance, $\varepsilon_l$ [keVm] | 5.3 | 6.0 |
| IBS growth factors hor./ver./long. | 1.5/1.1/1.2 | 1.5/1.1/1.2 |
| RF Voltage, $V_{RF}$ [MV] | 4.5 | 5.1 |
| Stationary phase [$^o$] | 62 | 51 |
| Synchrotron tune, $Q_s$ | 0.0065 | 0.0057 |
| Bunches per train, $n_b$ | 312 | 156 |
| Bunch spacing, $\tau_b$ [ns] | 0.5 | 1 |
| RF acceptance, $\varepsilon_{RF}$ [%] | 1.0 | 2.4 |
| Harmonic number, $h$ | 2851 | 1425 |

## ➢ Challenges

- Intra-beam Scattering (IBS) ➡ Special TME with def. dipoles
- Space-Charge(SC)
- Coherent Synchrotron Radiation (CSR)
- Transverse Mode Coupling Instabilities (TMCI)
- Ion/electron cloud instability

# Requirement for HALHF positron damping rings?

| | Injected | | Extracted |
|---|---|---|---|
| Bunch population ($10^{10}$) | | 3 | |
| Number of bunches/train | | 160 | |
| Bunch spacing (ns) | 16? | | 16? |
| Repetition rate (Hz) | | 100 | |
| Horizontal norm. emittance (um) | | | |
| Vertical norm. emittance (um) | | | |
| Bunch length (mm) | | | |
| Energy spread (%) | | | |