Comprehensive redesign of CLIC MB Injector

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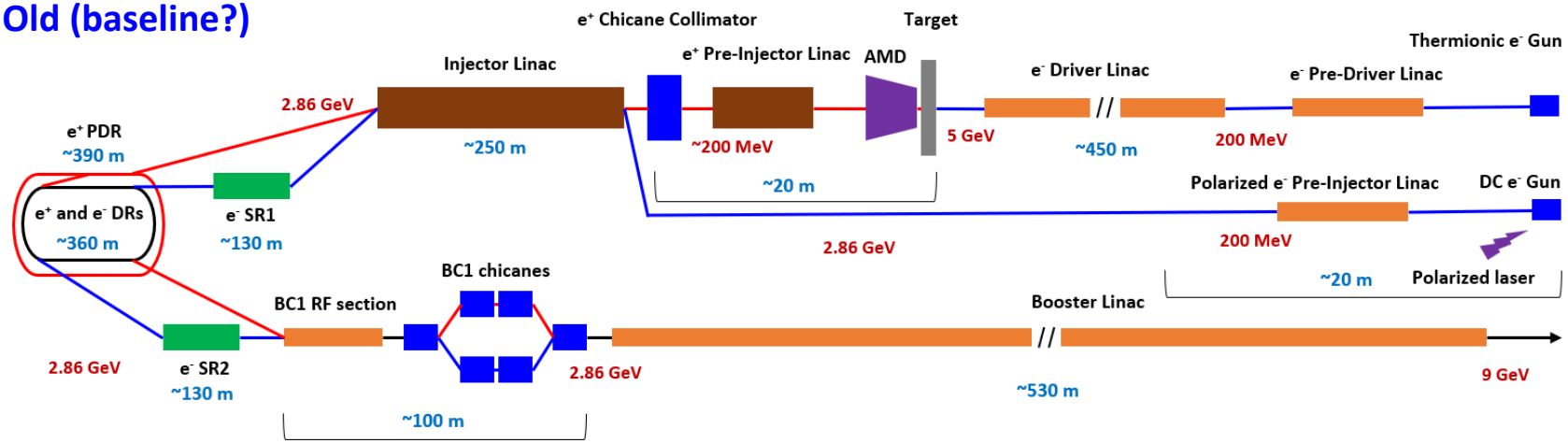
CLIC MB Injector Meeting

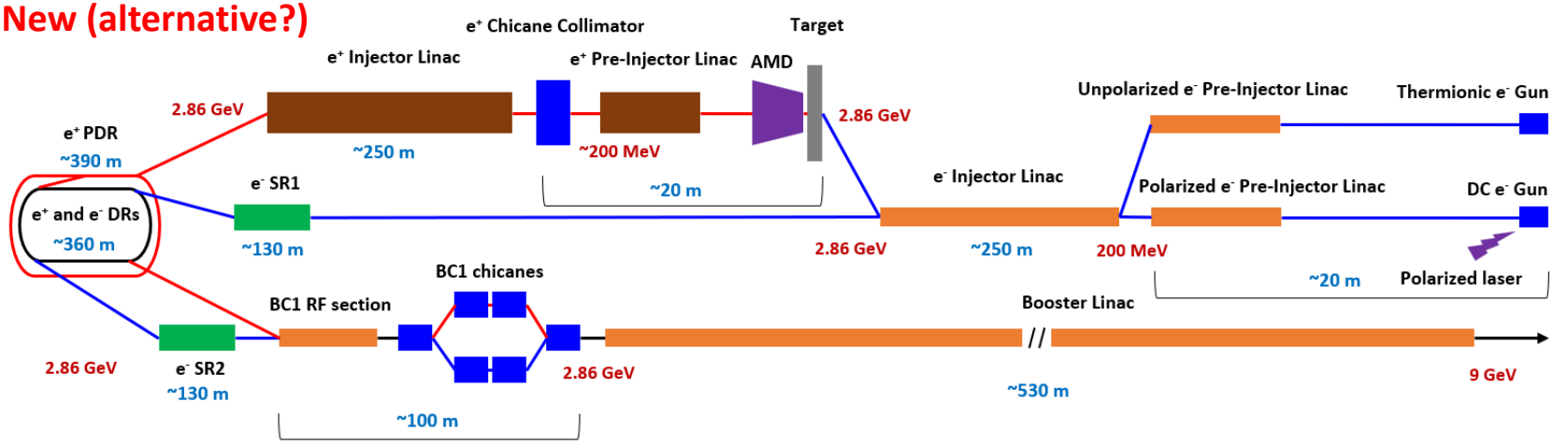
21/11/2024

Layout

- **Old (baseline?)**



- **New (alternative?)**

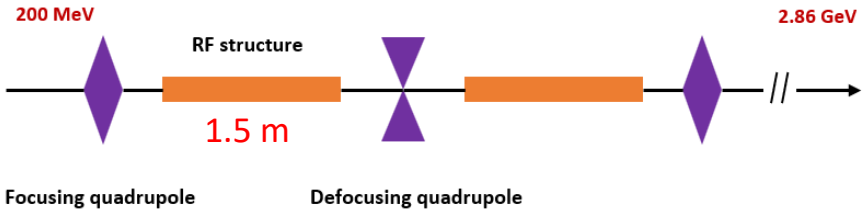


Preliminary. Not to scale.

AMD: Adiabatic Matching Device	SR1: Spin Rotator 1
PDR: Pre-Damping Ring	SR2: Spin Rotator 2
DR: Damping Ring	BC1: Bunch Compressor 1

e- Injector Linac

- Layout



- RF structure
  - f = 2 GHz, L = 1.5 m, $\Delta\phi = 2\pi/3$ per cell, $N_{cell} = 30$, G = 15 MV/m, $\phi = 0°$
  - $a_0 = (16+14)/2 = 15$ mm, $d_0 = (4.16+4.76)/2 = 4.46$ mm
- Beam parameters (DBA @ 380 GeV)
  - $\delta_E = 1\%$, $\sigma_z = 1$ mm, $Q_b = 1$ nC
  - Polarized e-: $\varepsilon_{n,x,y} = 10$ um, Unpolarized e-: $\varepsilon_{n,x,y} = 50$ um
- FODO lattice
  - FODO phase advance: 76.345°, k1 ~ 1.4715 m^{-1}

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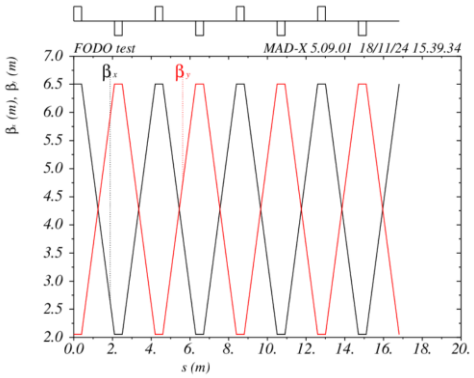
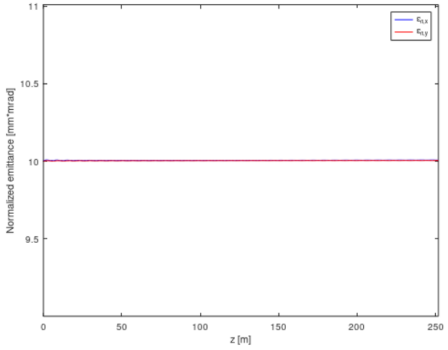
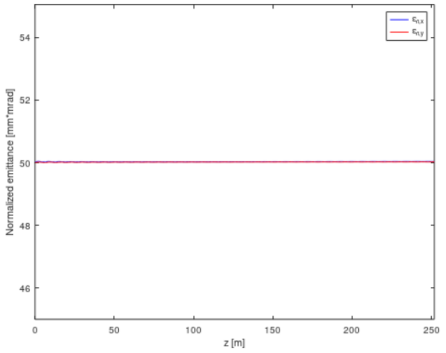
- 60 FODO cells, 120 structures.

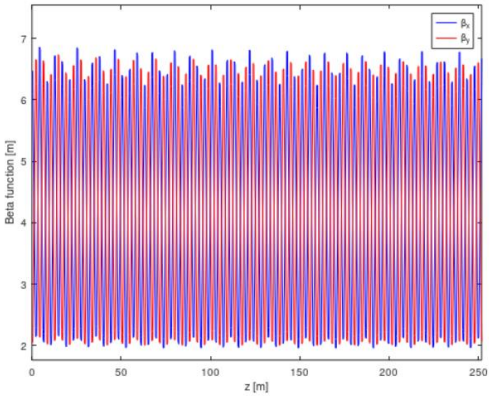
Twiss matching in MAD-X

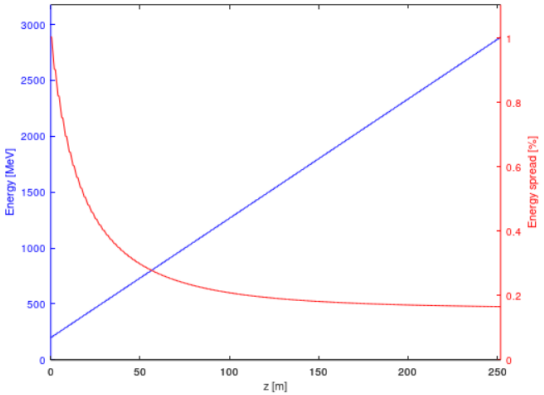


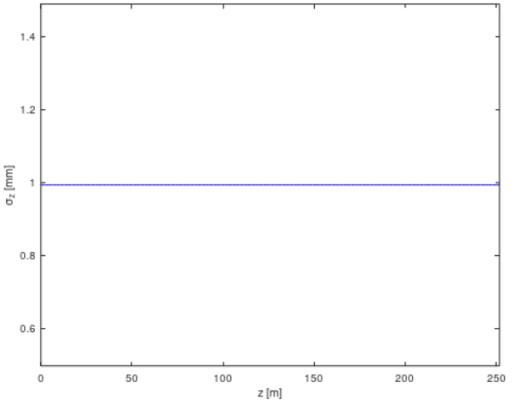
Full bunch tracking in RF-Track











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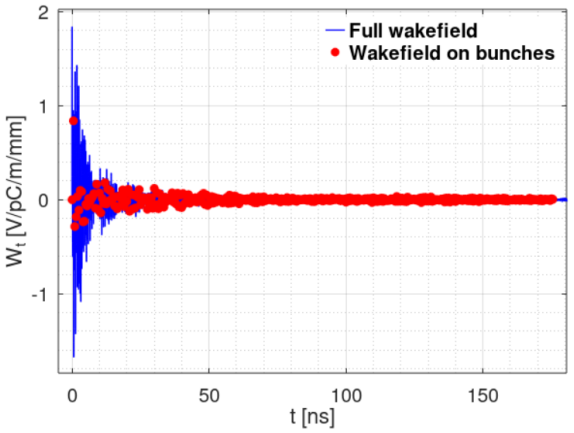
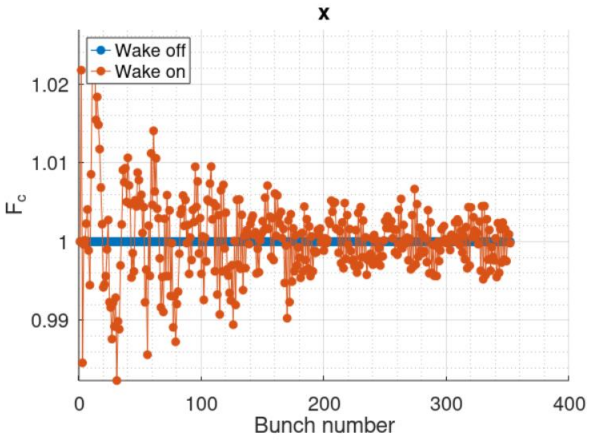
- Jitter amplifications (original wakefield from Adnan for 3 m structure)

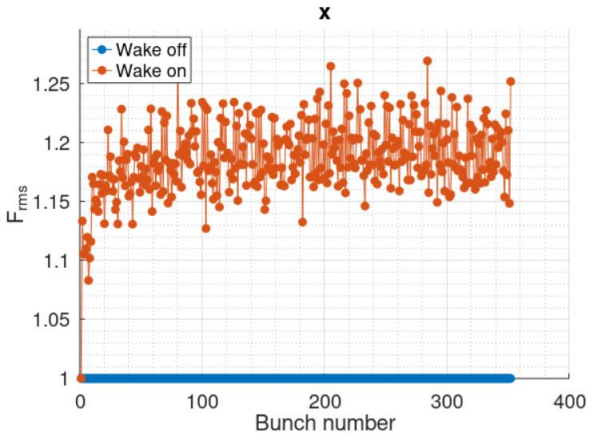


Sum(|Wt|) = 9.86 V/pC/m/mm

Single particle tracking in RF-Track with 1.5 m structure.

Jitter amplification factor	x	y
Coherent (average)	1.000	1.000
Coherent (maximum)	1.023	1.023
Incoherent (average)	1.186	1.062
Incoherent (maximum)	1.269	1.109





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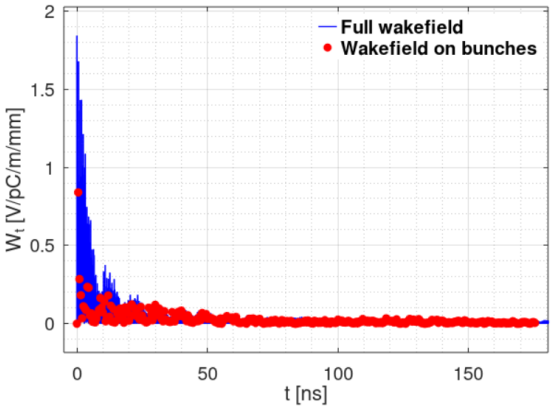
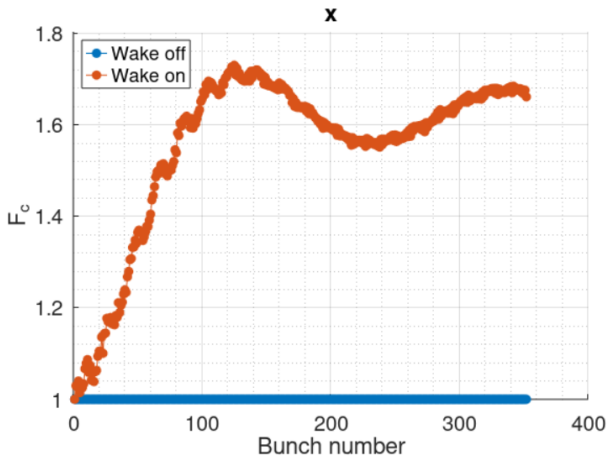
- Jitter amplifications (absolute wakefield)

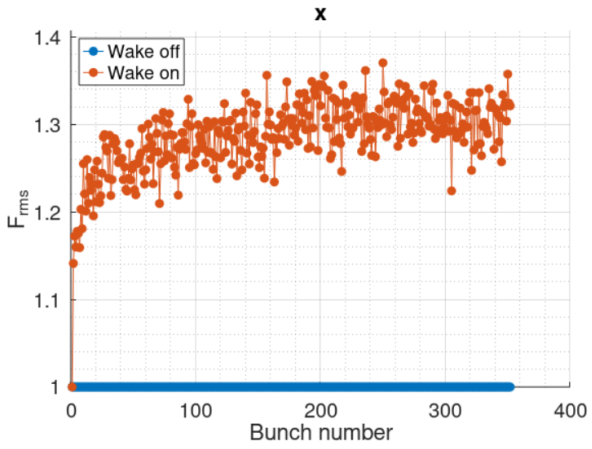


Sum(|Wt|) = 9.86 V/pC/m/mm

Single particle tracking in RF-Track with 1.5 m structure.

Jitter amplification factor	x	y
Coherent (average)	1.552	1.550
Coherent (maximum)	1.731	1.729
Incoherent (average)	1.287	1.113
Incoherent (maximum)	1.370	1.166





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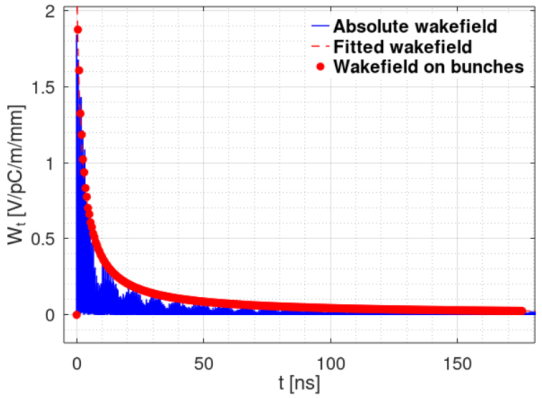
- Jitter amplifications (fitted absolute wakefield)

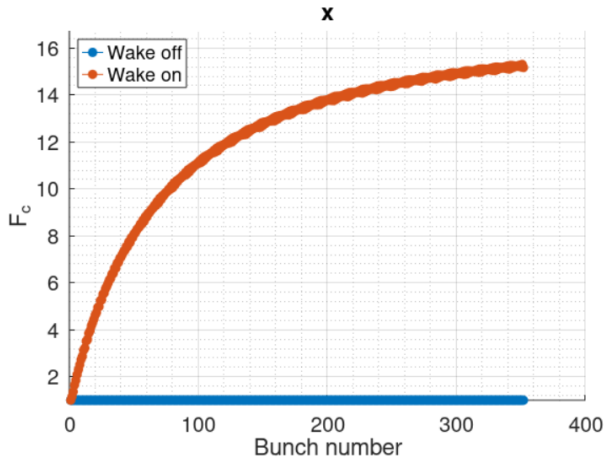


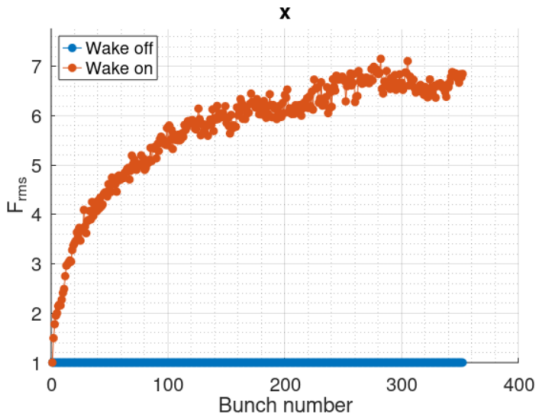
Sum(|Wt|) = 39.87 V/pC/m/mm

Fitting function: $W_{\perp(t)} = \frac{k}{1+\frac{t-T}{\alpha}} = \frac{1.8\ \mathrm{V/pC/m/mm}}{1+\frac{t-T}{2.5\ \mathrm{ns}}},\ t \geq T = 0.5\ \mathrm{ns}$

Single particle tracking in RF-Track with 1.5 m structure.

Jitter amplification factor	x	y
Coherent (average)	12.041	11.920
Coherent (maximum)	15.304	15.112
Incoherent (average)	5.730	4.827
Incoherent (maximum)	7.154	6.096





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- Imperfections and Beam-Based Alignment
- Imperfections considered
  - **Position** error (x, y): σ = **100 um**
  - **Angular** error (roll, pitch, yaw): σ = **100 urad**
  - **BPM resolution**: **1 um**
  - **Following errors not considered for now:**
    - ~~Magnatic **strength** error: σ = **0.1%**~~
    - ~~RF **gradient** error: σ = **1%**~~
    - ~~RF **phase** error: σ = **0.1°**~~
    - ~~Beam **position jitter** (x, y): σ = **100 um**~~
    - ~~Beam **angular jitter** (x', y'): σ = **100 urad**~~

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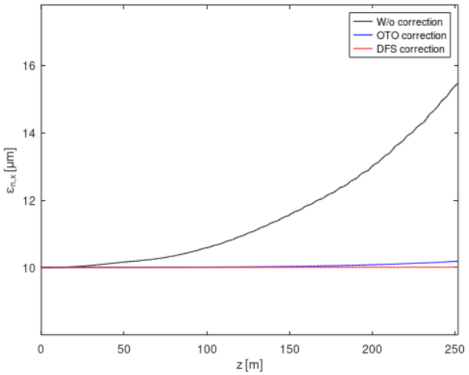
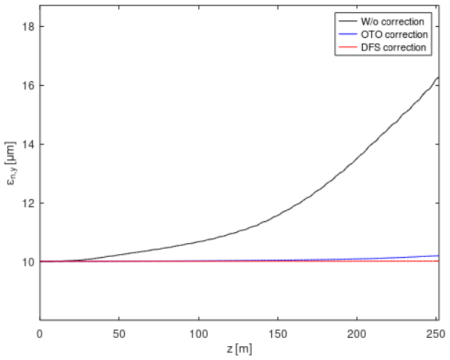
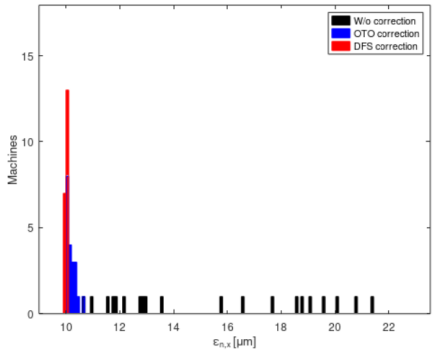
- Imperfections and Beam-Based Alignment

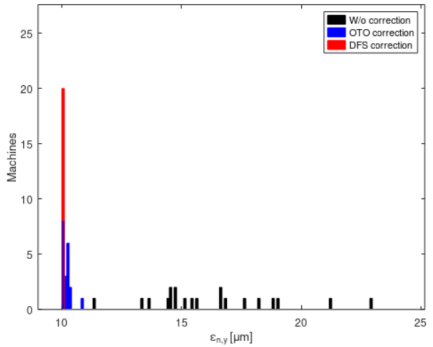
20 machines simulated for now.





Average emittance growths





Final emittances

Next steps

- To do:
  - Finalize **e- Injector Linac** study
  - Restudy **Positron Source** for new layout
  - Restudy **RTML** for new layout
  - CLIC Project Meeting presentation
  - IPAC’25 poster and paper

BACKUP

Design of new layout

- Electron source

Electron source	Particle	Final energy	Simulation
DC e- Gun	Polarized e-	~MeV	-
Thermionic e- Gun	Unpolarized e-	~MeV	-
Polarized e- Pre-injector Linac	Polarized e-	200 MeV	-
Unpolarized e- Pre-injector Linac	Unpolarized e-	200 MeV	-
e- Injector Linac	Polarized e- Unpolarized e-	2.86 GeV	RF-Track

- Positron source:
- PDR, DRs: not to simulate
- SR, BC1, BL: included in RTML simulation