Compact

Funded by the European Union

A proposal for a very compact injector using an S-band gun and x-band acceleration

- Simulation parameters
- Results
- Conclusion

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CompactLight requirements

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CompactLight target parameters

Beam Energy	Energy Spread	RMS Bunch Length	Bunch Charge	Emittance	Peak Current
300MeV	$\leq 0.5\%$	$\approx$ 350 fs	75 pC	$< 0.2\ \mu m$	60 A

- High repetition rate needed 100 - 1000 Hz

Injector Design

Philosophy: Use S-band rf-gun because of its well established performance (cathode, laser, magnets)

Use X-band for velocity bunching and acceleration

CERN has experience and hardware for those frequencies

RF- parameters

Parameter	RF Gun	Buncher	Acc
Frequency	3.0	12.0	12.0
Gradient	$120 MV/m$	$< 65\ MV/m$	$65\ MV/m$
N. Cell	1.6	120	120

INFN-type RF gun , CompactLight x-band structure used

Using ASTRA for simulations

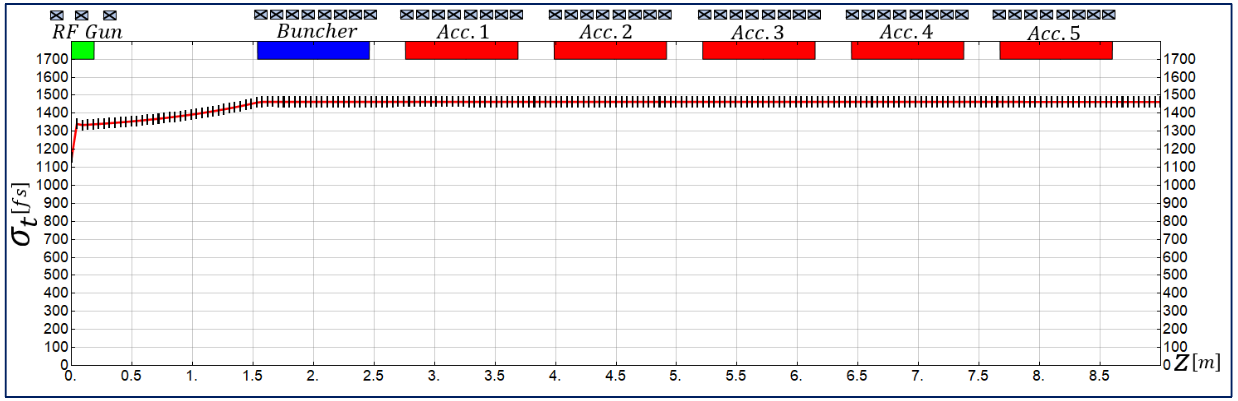
Laser parameters, uniform distributions

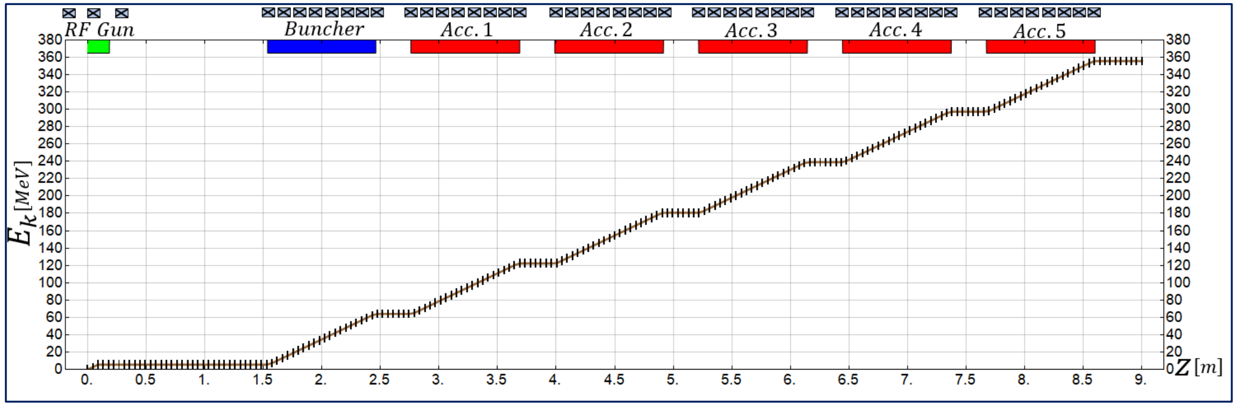
$\lambda[nm]$	$w[ev]$	$r[mm]$	$t[ps]$	$q[pc]$
262	4.31	0.3	4.0	75

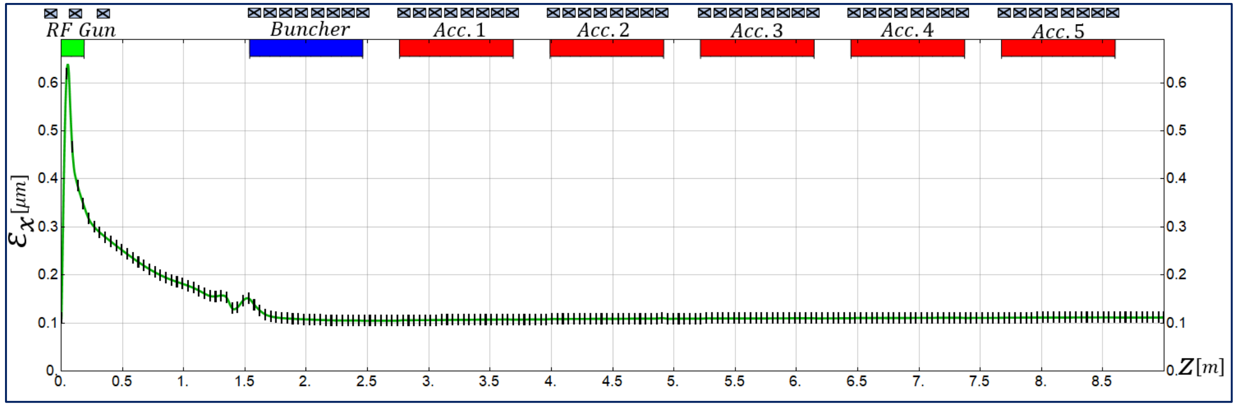
Thermal emittance 0.08 um (copper)

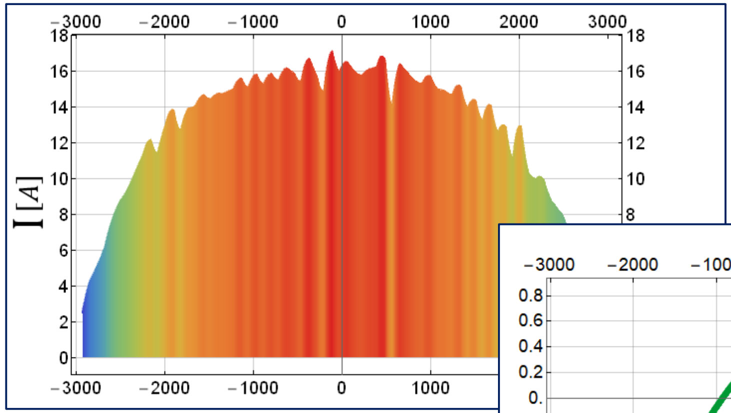
Case 1 : simply acceleration no bunching

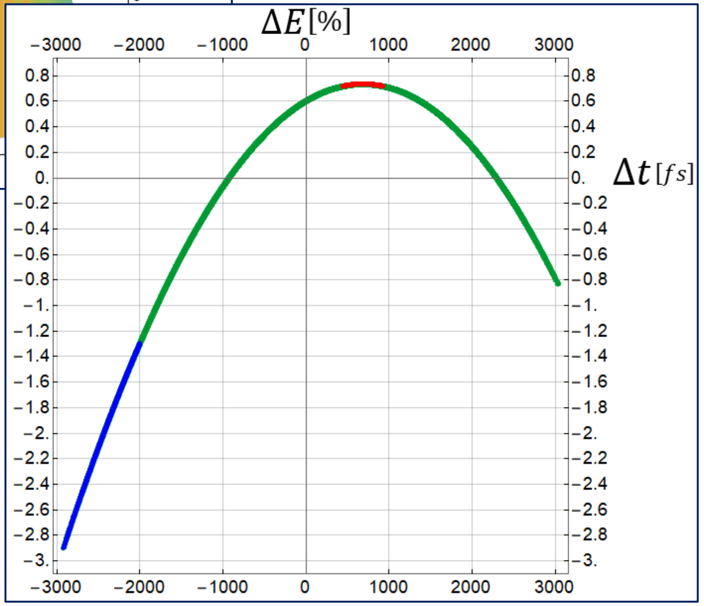
Component	$F\ [GHz]$	$E\ [MV/m]$	$N.Cell$	$\varphi[deg]$	β
RF Gun	3	120	1.6	30	-
Buncher	12	65	108	90	0.996
Acc.1	12	65	108	90	1.000
Acc.2-5	12	65	108	90	1.000







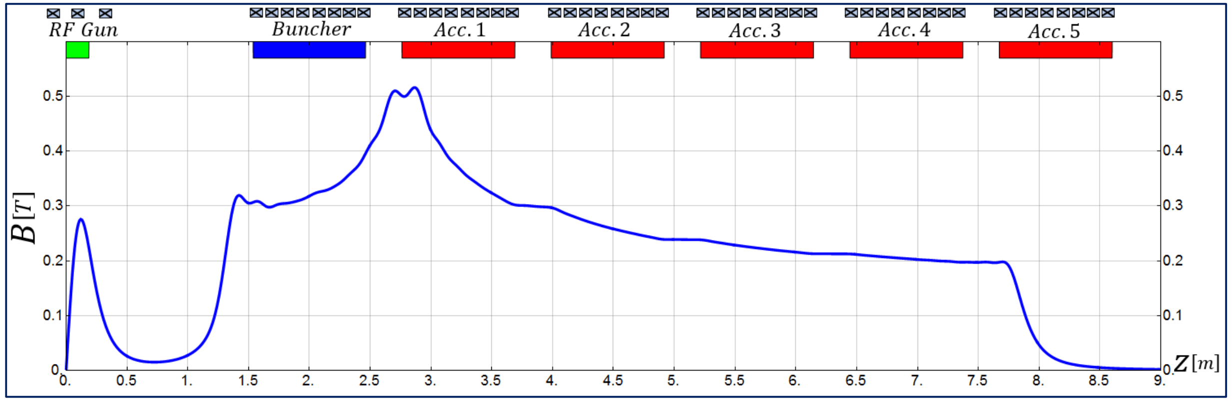


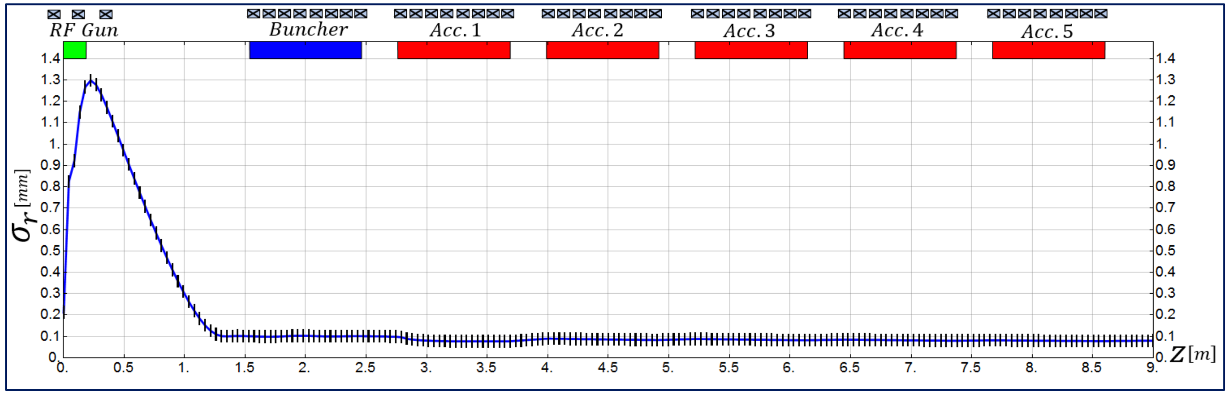


$E_k[MeV]$	$\sigma_r[mm]$	$\sigma_t[fs]$	$\varepsilon_x[\mu m]$	$\sigma_E[\%]$	$I_{av}[A]$
356	0.1	1462	0.111	0.82	15

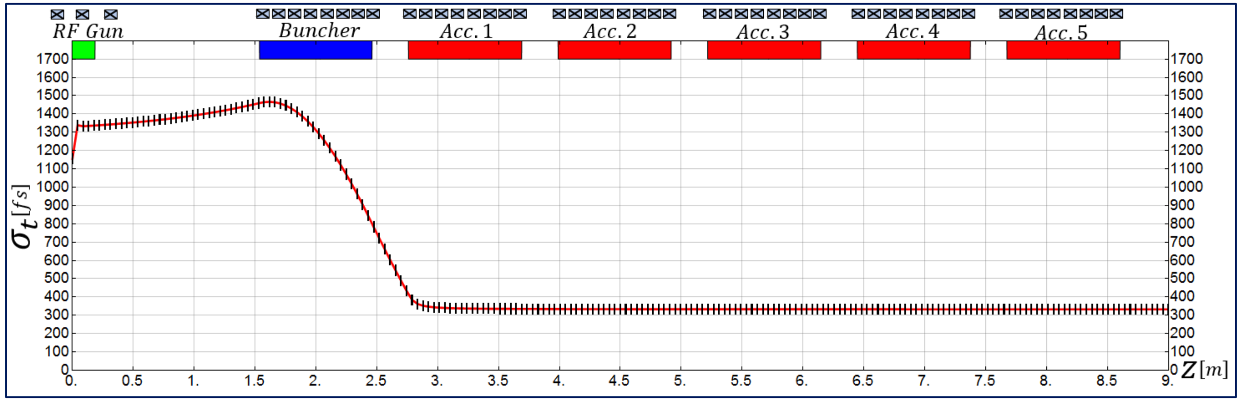
Case 2 : velocity bunching to 332 fs

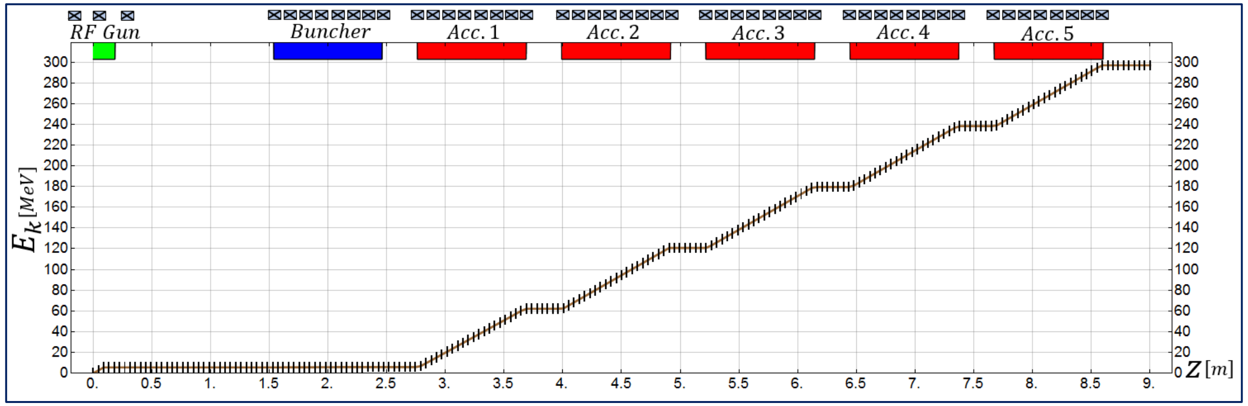
Component	$F\ [GHz]$	$E\ [MV/m]$	$N.Cell$	$\varphi[deg]$	β
RF Gun	3	120	1.6	30	-
Buncher	12	5.2	108	10	0.996
Acc.1	12	65	108	70	1.000
Acc.2-5	12	65	108	87.5	1.000

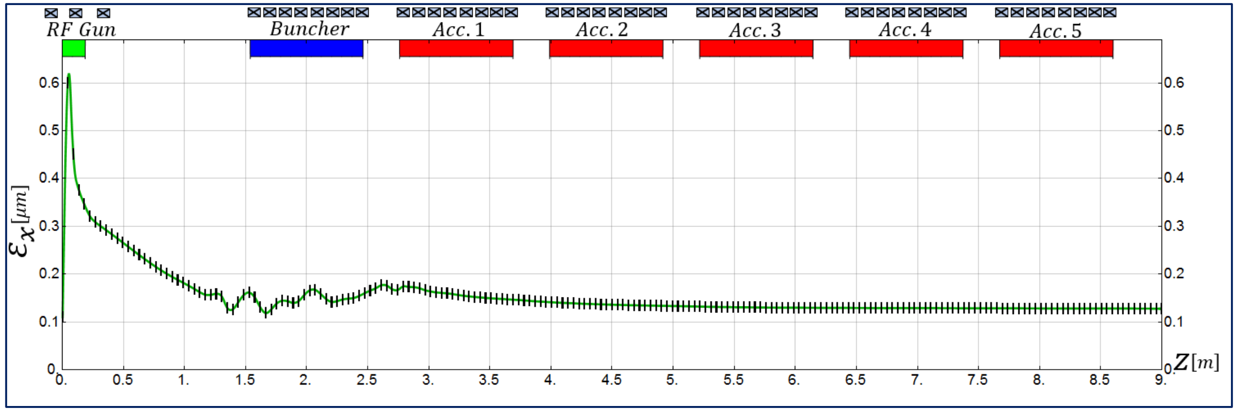




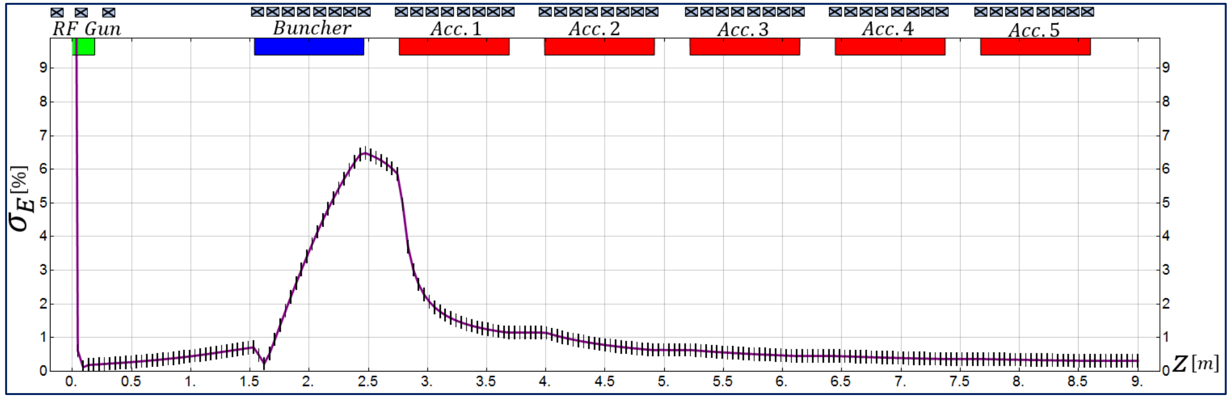
$E_k[MeV]$	$\sigma_r[mm]$	$\sigma_t[fs]$	$\varepsilon_x[\mu m]$	$\sigma_E[\%]$	$I_{av}[A]$
297	0.1	332	0.13	0.31	65

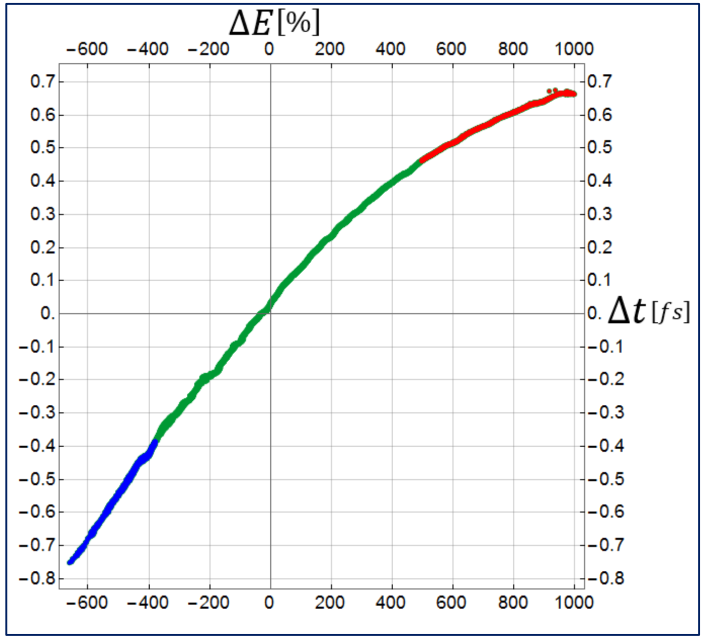


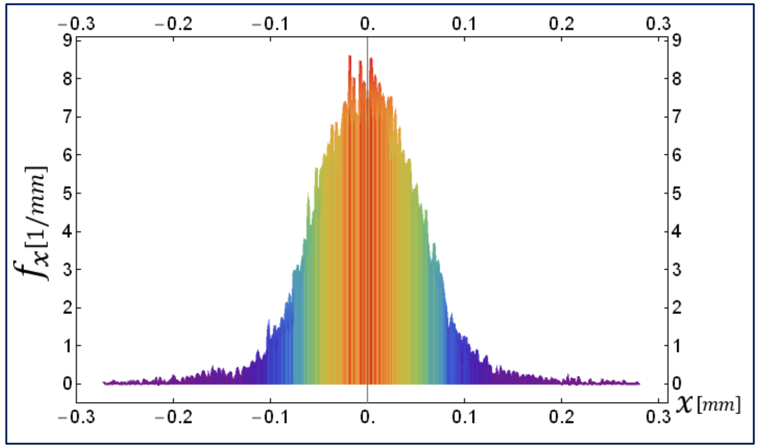


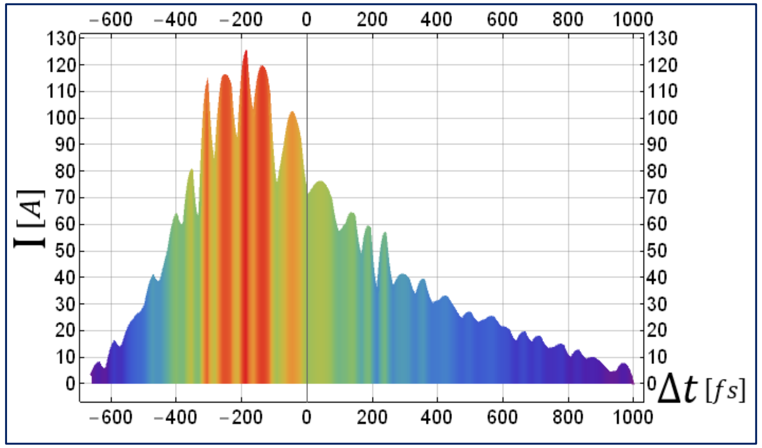


Case 2 : velocity bunching to 350 fs





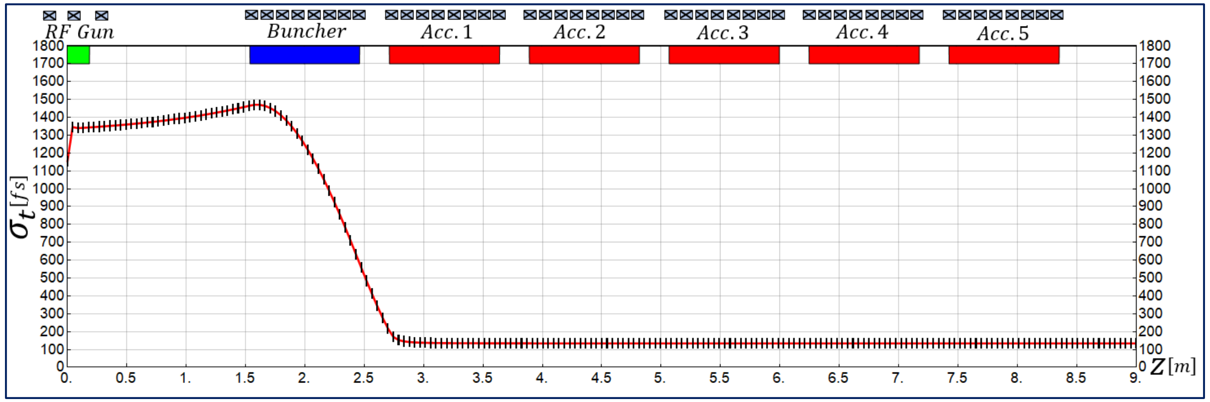


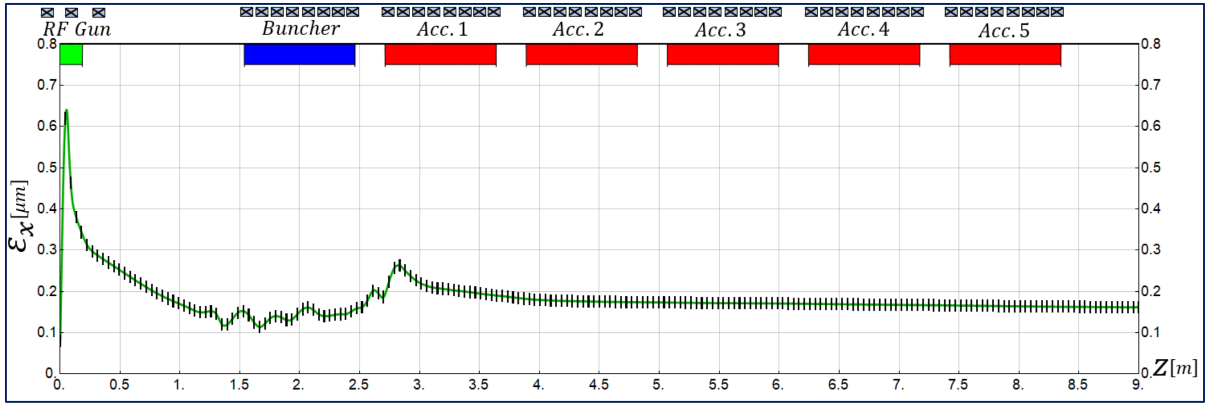


This case has been used for subsequent Linac simulations (see WP 6 presentations by Xingguang Liu)

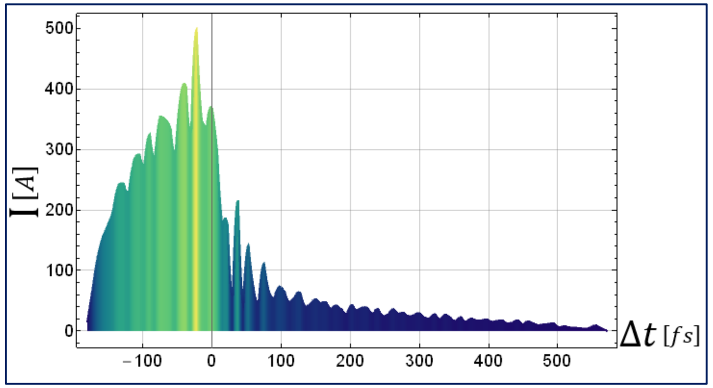
Case 3 : velocity bunching to avoid first bunch compressor

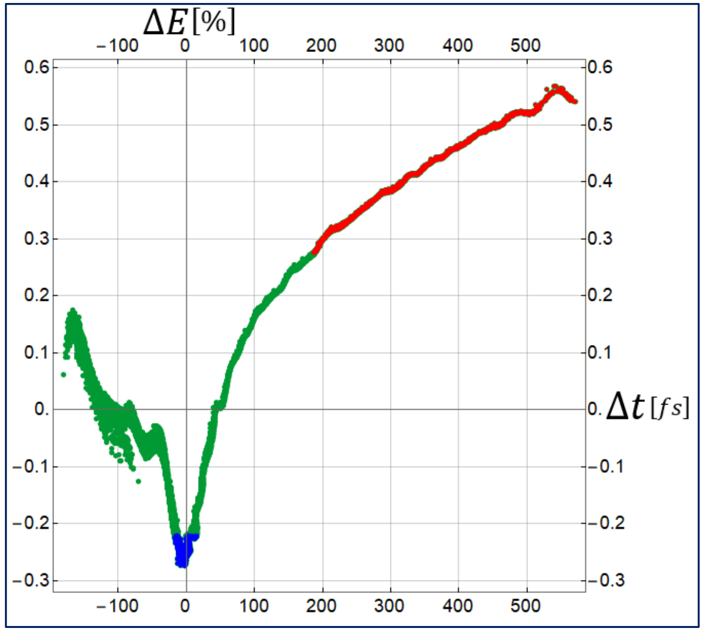
Component	$F\ [GHz]$	$E\ [MV/m]$	$N.Cell$	$\varphi[deg]$	β
RF Gun	3	120	1.6	30	-
Buncher	12	7.0	108	10	0.996
Acc.1	12	65	108	70	1.000
Acc.2-5	12	65	108	87.5	1.000





$E_k[MeV]$	$\sigma_r[mm]$	$\sigma_t[fs]$	$\varepsilon_x[\mu m]$	$\sigma_E[\%]$	$I_{av}[A]$
297	0.1	133	0.16	0.18	162





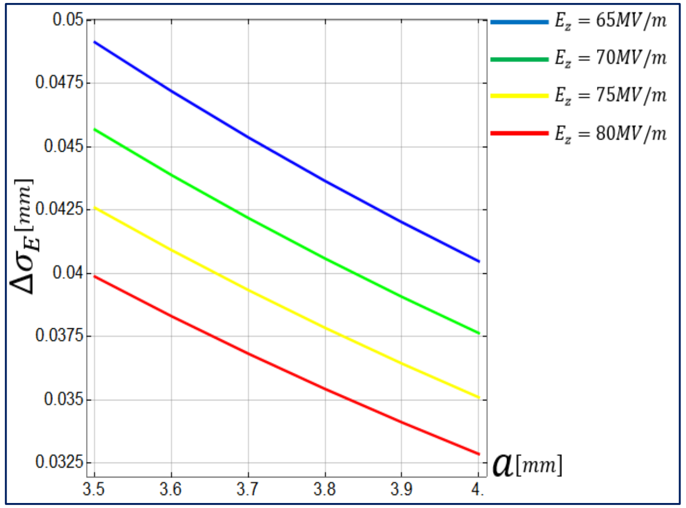
Wake field considerations

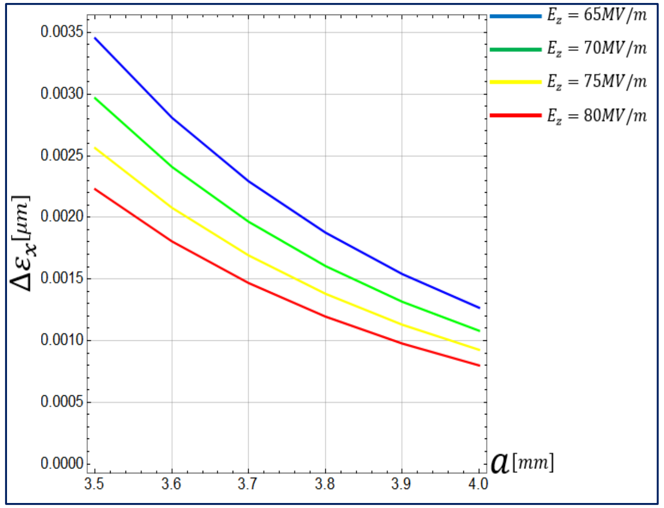
We don't have the full 3D field map of the CompactLight x-band structure yet

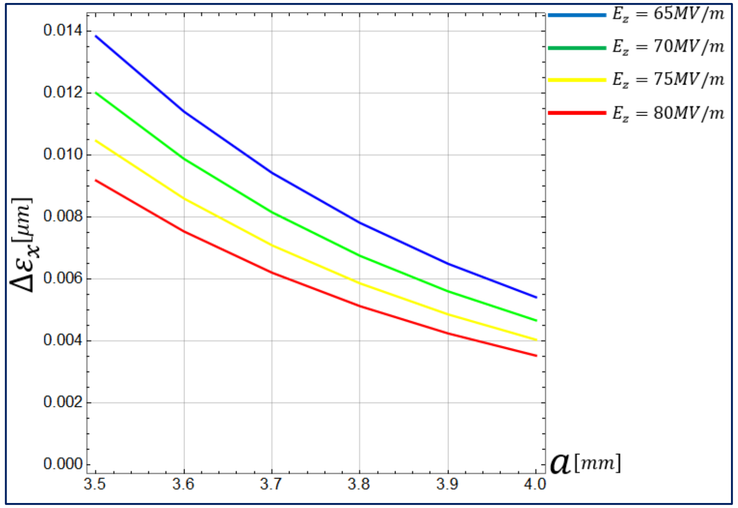
First analytical (worst case) look into longitudinal and transverse wake fields (350 fs case)

Longitudinal wakes

Transverse wakes, 50 μm (0.5 sigma) and 100 μm (1 sigma) offset







Wake field effect within the injector seems quite small

Conclusion and Outlook

- Proposal of a very compact injector with proven gun technology
- x-band modules could be used from the beginning providing a very compact and flexible design, no need for other frequency module
  scheme might work with different gun-types
- S-band gun allows for flexibility in cathode material and laser set-up
- Further transport of the beam and its suitability for FEL needs study
  (see WP 6 presentations by Xingguang Liu)
- Scheme makes most sense with moderate – strong velocity bunching and if it is possible to work without linearizer

- We will continue looking into wake fields and tolerances for this type of injector